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OUTLOOK ON AGRICULTURE

VOLUME I NUMBER 1

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Communications should be addressed to the Editor, E. J. McNaughton, B.Sc. (Hons.), B.Sc. (Agric.), Imperial Chemical Industries Ltd., Jealott's Hill Research Station, Bracknell, Berkshire, England

A PERSONAL MESSAGE

from Sir Alexander Fleck, K.B.E., F.R.S.

Chairman of Imperial Chemical Industries Limited

Agricultural techniques today are complex, and those who are involved in agricultural development need not only a thorough understanding of the accumulated lore of husbandry but also more than a passing acquaintance with the scientific background to agricultural practice.

There exists, I believe, a real place for a journal which will be issued not more than two or three times a year and which will have the stimulating title of OUTLOOK ON AGRICULTURE. *It will review some of the fundamental problems involved in the science and describe the most modern techniques that have been evolved for dealing with them.*

I am glad that it is through the initiative of the agricultural organisations within I.C.I. that this new journal has come into being. I extend my best wishes to its sponsors and a warm welcome to its readers. I feel sure it will quickly establish itself as it progresses steadily to its objective.

Alexander Fleck

FOREWORD

S. W. Cheveley

The chairman of Central Agricultural Control of Imperial Chemical Industries Ltd. outlines the purpose of the Company in producing this new journal.

It is with pleasure that I write a foreword to this first number of the journal Outlook on Agriculture.

The principal reason for this publication by Central Agricultural Control is to bring together under one cover the wide variety of contributions on agricultural subjects, mainly of a technical nature, which in the past have been circulated from a number of different sources within Imperial Chemical Industries Ltd. It is a logical step in the closer integration which has been steadily developing within I.C.I. of the three main interests of the Company in world agriculture, namely crop production, crop protection, and animal health.

I.C.I.'s interest in agriculture continues to expand, and new agricultural outlets are being found for products originally designed for industrial uses, such as metals and plastics for water supplies and buildings, and bactericides and detergents for farm hygiene.

Outlook will be available wherever I.C.I. and its associated organisations have an interest in agriculture. At the moment we are planning two issues annually; in time we may achieve more. In scope Outlook will cover the widest possible field of technical and general knowledge under the three headings mentioned, drawing on all the resources and facilities of the Company's comprehensive research and technical development organisations.

There will be sections devoted to abstracts from the technical journals and reviews of important books in the agricultural and biological fields. An editorial board has been formed to assist in matters of editorial policy, and the Editor, Mr. E. J. McNaughton, centred at our Agricultural Research Station, Jealott's Hill, Bracknell, Berks, will obtain articles from experts in their respective fields from in and outside the Company. The intention is a completely objective presentation of world agricultural problems and progress within the I.C.I. sphere of interest.

The background to this is an imposing structure of research organisation, covering by fundamental and applied work much of the wide chemical and biological field in agriculture, together with an organisation devoted to economic research in this field.

Within the orbit of Central Agricultural Control, Plant Protection Ltd., and the Pharmaceuticals Division there are specialised staff actively concerned with the study of agricultural problems of interest to I.C.I. They are responsible, with associated organisations, for fact-finding surveys, for the planning of experimental work, and for advice on specific problems. With this background we feel confident that Outlook on Agriculture will not belie its title.

Research the world over, not least in Britain and the Commonwealth, is being used increasingly to raise the output of food for mankind and reduce the losses from pests and diseases among the crops and livestock on which man depends for survival.

The translation of research findings into general practice has always been a slow, and sometimes a discouraging, process. The printed word is but one means to speed up this process, and it is hoped that Outlook will play a useful part in furthering agricultural knowledge and the application of new techniques.

Less than ten years ago views on increasing populations and the shrinkage of land areas available for food production were almost generally pessimistic. A feeling existed that only miracles could save humanity from the many disasters inevitable in a famine-stricken world. More recently world output of food is reported to have increased by about 20%. Some nations are achieving large agricultural surpluses, and even in the more backward areas agricultural progress is becoming evident.

There is reason to hope that the world is emerging from nearly two decades of wars and disturbance into a calmer atmosphere, where the minds of men may escape from destructive considerations to those of raising the standards of living and of health by better nutrition, thus engendering a period of peace and progress.

It is in this atmosphere that the first number of Outlook on Agriculture is presented to its readers.

UTILISATION OF GRASSLAND

R. A. Hamilton

Young grass is the ideal food for the grazing animal. It is rich in all essential nutrients and is cheaper to produce than most other feeds. The chief aims of the livestock farmer must be to get plenty of young grass for grazing in early spring and late autumn, when it is most needed, and to conserve any surplus, particularly as silage, for winter feeding. This will make his farm more self-supporting and lower the cost of livestock products.

If full use could be made of the food nutrients produced by the grasslands of the world there would be food in abundance, and at the lowest cost, particularly the animal products which are in greatest demand today.

Something like two-thirds of the agricultural land of the world is in permanent meadows and pasture, and account must also be taken of the acreage of temporary leys in the arable rotations of many countries. In the United Kingdom more than half the food nutrients obtained from our own soil comes from grassland. Of our 31 million acres of agricultural land over 19 million acres are in grassland, and there are in addition 17 million acres of rough grazings.

Grass is the raw material from which we get much of our milk, meat, butter and cheese; but in converting grass or indeed any other form of livestock feed to the animal products we require there is a substantial loss of nutrients. The efficiency of conversion of animal feed by different types of livestock is illustrated in Table I (after Hammond).

TABLE I

EFFICIENCY OF ANIMAL PRODUCTION

Product	Protein conversion efficiency (%)	Energy conversion efficiency (%)
Milk (3 lactations) ..	17·0	30·0
Eggs (2 years)	33·1	22·1
Beef (grass-fattened to 10·7 cwt.)	7·3	15·1
Pork	13·8–16·0	34·4–39·4
Lamb	5·9	9·6

The facts brought out in this table are of the utmost importance in relation to future world food supplies. It is known that, as real incomes and standards of living increase, dietary customs change and gradually people eat less tillage crops and more animal products. The trend is for the consumption of cereals and potatoes per head of population to fall and that of meat and dairy produce to increase. This trend in dietary habit will put an ever-increasing strain on the supply of basic food nutrients because such a high proportion of these is lost in conversion to the finished animal products.

In a world whose population is expanding at the rate of two million per month the need to make the most efficient use of grass, the acreage of which exceeds that of all other crops combined, is self-evident. In Britain it is now accepted that to make better use of our grasslands is an economic necessity. Yet, at a time when balance of payments fears are growing daily, our expenditure on imported animal feedingstuffs has increased by £55m. in the last two years, and much of this could have been supplied at very much lower cost by better utilisation of grassland.

TABLE II

ESTIMATED COST OF STARCH EQUIVALENT FOR VARIOUS CROPS AND DAIRY CAKE IN 1954

	Average yield per acre (tons)	Cost of S.E.* (£ per ton)
Grazing (effective production) ..	—	11
"Early bite" (effective production)	—	14
Grass silage	5·2	17
Kale, grazed	14·0	17
Kale, cut	20·0	18
Hay	1·7	20
Oats, half straw-fed	1·2	28
Fodder beet, roots	12·0	33
Tillage silage	6·0	34
Dried grass	1·6	40
Mangolds	25·0	40
Dairy cake at £35 a ton (65% S.E.)	—	54

* S.E. = Starch equivalent, which is the number of pounds of starch necessary to produce the same amount of fat as 100 lb. of the food.

Grass well managed can produce greater yields of nutrients for livestock than almost any other crop, and the cost of nutrients from grass is low compared with those obtained from any other source, as is seen from Table II.

These figures show that grass consumed as grazing is by far the cheapest feed for ruminants, that conserved grass is cheaper than most other feeds, and that all forms of grass are substantially cheaper than purchased cake. It will clearly be to the advantage of the livestock farmer to achieve the highest possible output from his grassland and provide as much as possible of the nutrient needs of his stock through grazing.

OUTPUT FROM GRASSLAND

Unfortunately, in considering grassland output we are soon in difficulty because of the lack of a method of measurement that is suitable and generally applicable. Where only one type of livestock is used to consume grass, and where the livestock are fed entirely from the grass, there is no problem; but, in general, grass is consumed by a variety of livestock of different ages and frequently other foods are used to supplement the grass, so that the problem becomes much more complicated. To try to assess grassland output by measuring weight and composition of grass produced is seldom satisfactory and often misleading. The method in most common use aims at assessing the output of utilised nutrients in terms of starch equivalent: an estimate is made of the total food required by the stock consuming the grass, and from this is subtracted the nutrient value of any other material fed, and the difference is considered to be the contribution from grass in terms of starch equivalent. This method has many shortcomings, but it is one of the most useful available for comparative purposes.

Using this method, an O.E.E.C. working party, in a recent survey of pasture and fodder production in north-west Europe, arrived at the following estimates for average grassland output in the countries surveyed. For comparative purposes the average yield of barley (20 cwt. per acre) in the United Kingdom in 1952 was equivalent to 14·2 cwt. starch equivalent per acre.

Grassland output in the Netherlands is by these standards reasonably satisfactory, and is equivalent to a yield of about 37 cwt. of barley; but output of grass in several other countries, including the United Kingdom, is still low, and there is a weight of evidence to indicate that much higher production is possible. For example, one group of 47 farms in the United Kingdom for which detailed records are available recorded an average yield of 23 cwt. utilised starch equivalent per acre over 7000 acres of grassland in 1953; some of the farms exceeded 30 cwt. per acre; two farms exceeded 35 cwt. per acre. Further records show that one small 32-acre farm achieved an output of 42 cwt. utilised starch equivalent per acre. Few arable crops will produce yields of this order.

TABLE III

ESTIMATED PRODUCTION FROM GRASSLAND, 1951–2 (O.E.E.C.)

Country	*S.E./acre* (*cwt.*)
Netherlands	26·2
Denmark	22·3
Belgium	20·0
Norway	19·0
W. Germany	17·2
United Kingdom	16·7
France	11·1

What is the secret of the high output from grassland on these latter farms? Is it that their conditions are more suited to high grass yields than most other farms? Almost certainly not. They undoubtedly grew good crops of grass, but above all they made the most efficient use of the grass they grew.

High output from grassland means growing a good crop of grass and making the best use of it, and in the present state of our knowledge the latter part of the procedure demands greater thought, skill and planning than the former. This fact is well demonstrated by a quotation from McMeekan [2] in respect of New Zealand grassland. He writes:

"Measured annual yields from good-quality dairy pastures in New Zealand approximate 9000 lb. dry matter per acre. Though perhaps the most highly specialised grassland dairy country in the world, the average yields from such swards today is only 150 lb. butterfat per acre (300 gal. at 5% b.f.)—an efficiency of conversion index of 1 lb. butterfat from 60 lb. pasture dry matter. Even a low-producing dairy cow yielding only 300 lb. butterfat (600 gal. at 5% b.f.), needing and consuming 9000 lb. of pasture dry matter in the process, has an efficiency index of 1 lb. of butterfat from 30 lb. of dry matter. Thus, even in one of the best environments, utilisation is only 50% of the potential."

Obviously full use is not being made of all the grass. McMeekan [2] has aptly remarked: “Pasture is useless unless usable.”

MAKING THE BEST USE OF GRASS

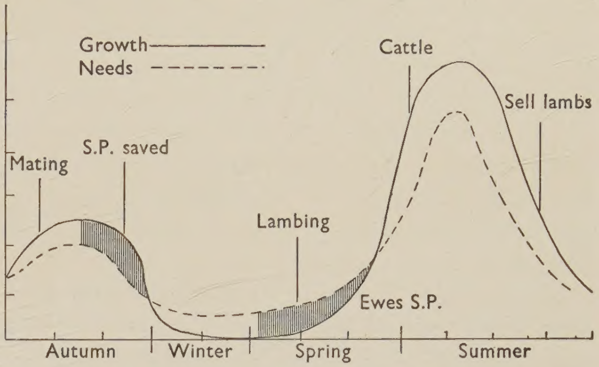
What are the rules, then, for making the best use of grassland? One must admit at once that in this important field of grass utilisation our information is woefully inadequate, and it must be true to say that we have only touched the fringe of the subject.

The utilisation of grass is, of course, closely linked with its production, which is influenced by three groups of factors. Firstly, there are the natural factors of soil, climate, topography, etc., all of which affect the growth of grass through their effect on temperature, soil moisture, etc. Secondly, there are the natural forces within the plant which control its characteristic cycle of growth. Lastly, there are management factors which include the choice of species and strains of grass, the use of fertilizers to extend the growing season as well as to improve the yield and quality of herbage, cultural practices, and frequency of sward defoliation.

Of the three groups of factors only the last is under the farmer’s control, the other two being natural phenomena which largely govern the characteristic pattern of grass growth and account for the marked fluctuation in herbage production during the growing season. Advances in plant breeding and grassland management have done much to even out this pattern of growth, but still it confronts the farmer. Although he can normally hope to extend the grazing season by some two to three weeks in the spring, and again in the autumn, through the judicious use of fertilizers, though too he may increase his supply of herbage during midsummer by the use of maiden seeds and so on, he must nevertheless acknowledge that herbage production follows a characteristic seasonal pattern of growth over which he has only limited control.

The main problem of grass utilisation is to obtain a close fit between the pattern of grass growth and the nutritional requirements of the livestock. The aim must be to consume the maximum proportion of the grass as grazing because, as was shown in Table II, this is by far the cheapest method of using grass. It is seldom possible, however, to achieve so close a fit between pasture production and animal requirements that all the grass on a farm is consumed as grazing on an all-the-year-round basis. Other methods of using grass, therefore, must be adopted.

One of the best natural fits between pasture production and animal requirements is seen in the fat lamb industry of New Zealand. This is illustrated in Figure 1 (after McMeekan). The pasture shows the typical yield curve with a spring and early summer peak, followed by a lean period and then a smaller autumn peak, followed by a dormant winter period.



S.P. = saved pasture

FIG. 1. New Zealand pasture growth and fat lamb flock needs.

The New Zealand fat lamb farmer purchases cull ewes from the lower hills in late summer, and these are mated to lamb at the commencement of spring growth. A Southdown ram is used to give an early-maturing lamb with the object of selling most of them fat off the mother at 16–20 weeks when pasture growth declines with dry summer weather. After weaning, the remaining lambs are given the best of the pasture and the ewes run on bare pasture to bring them down in condition. They are then run on better autumn pastures to flush them for tupping, and this is followed by bare maintenance during mid-pregnancy. During this period grass is saved and stored *in situ* for feeding off to the ewes before lambing.

Stocking rates are high, varying from four to six or eight ewes per acre, and the ewes and lambs are set stocked, i.e. confined on individual fields from lambing to weaning, unless the lambs are sold fat before weaning. This may seem a surprising practice, as it might be expected that rotational grazing at these levels of stocking would give better results; but there seems no doubt that the young lamb thrives best under a set stocking system, even though at times the pasture may appear extremely bare.

In many cases cattle are introduced into the system when the growth of grass is nearing its peak. They are rotationally grazed, their function being to keep the pasture at the right stage for the sheep. As the food declines, they are sold fat. The cattle are only a tool in the system and add little or nothing to the financial returns but greatly facilitate efficient grass utilisation.

Output of meat by this system is high, the liveweight gain ranging from 400 to 600 lb. per acre, and the total number of lambs produced now exceeds 10 million annually—a remarkable figure when it is realised that sheep were only introduced into New Zealand in 1773.

In certain districts of New Zealand grass is not sufficient to supply all the winter requirements, and some arable crops, mainly roots, are grown; but, for labour reasons, the tendency is to try to extend the grazing season and rely on grass all the year round.

New Zealand fat lamb farming is one of the best examples of good grass utilisation—grass production is at a high level and very little is wasted. The result is low cost production. The system, however, is not devoid of difficulties and there are many problems, the solution to which will further enhance production. In this system—as in all efficient grassland systems—it is recognised that the farmer must be prepared to punish the pastures (or the stock, if need be), but at times when no irreparable damage is done and from which recovery can also be planned.

On the New Zealand dairy farm, however, the fit between production and animal needs is more complicated. None the less, grass in some form provides for the full needs of the dairy herd in most cases, and the system is worth examination. The cows are managed to calve in spring, and their nutritional needs and pasture growth curves are shown in Figure 2 (McMeekan). Here the rate of stocking is 60 cows to 100 acres. This means that there will be surplus grass at the peaks of growth, and all of this is conserved in one of three forms: hay, silage or saved pasture (foggage). The best pastures are always retained for the milking cows; but all grazing is controlled with the object of avoiding waste, and dry stock are used to clean up pastures. Hay is generally fed to dry cows in winter, and saved pasture and silage are fed to supplement spring pasture as the cows calve.

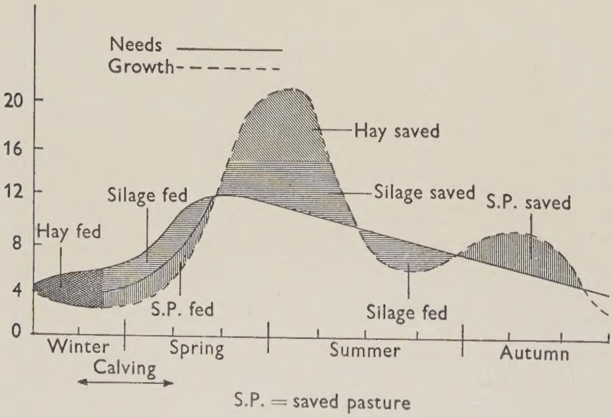


FIG. 2. New Zealand pasture growth and dairy herd needs.

The fit between grass production and utilisation is not nearly so good as in fat lamb production, yet grass production is high and there is a minimum of waste on the best farms, though because of the increased amount of conservation some waste is inevitable. Compared with the fat lamb farm, the dairy farm adopts rotation grazing as opposed to set stocking, and it has been found experimentally at Ruakura that by far the best system of calf rearing in New Zealand is to graze calves rotationally in front of the dairy cows.

These two systems based on relatively efficient utilisation of grass produce lamb and butter at lower costs than those of any other country. They are good illustrations of the fact that the closer the fit between seasonal grass production and nutritional needs of the livestock the more efficient will be the utilisation of the grass and, as divergence between seasonal grass production and nutritional needs increases, problems of grass production and utilisation also increase.

In New Zealand the grazing season is long. Maximum nutritional needs coincide with maximum grass production, and the principal livestock products are marketed in manufactured or frozen forms. In Britain, on the other hand, the grazing season is relatively short, and spread of nutritional needs is much greater because most of the livestock products are required in a fresh state all the year round. The result is that there cannot be a close fit between grass production and nutritional needs; hence the grassland farmer in Britain has to face more difficult problems in providing for his stock through grass than does his counterpart in New Zealand and, in general, grass in its various forms must be supplemented with other foods.

The challenge of the British or European grassland farmer is to try to fill the seasonal gaps between production and nutritional needs with the least loss of grass nutrients consistent with low cost. The first and most obvious step in filling the gaps in natural production is to use all the appropriate techniques available to lengthen the grazing season. This can be done both by using selected

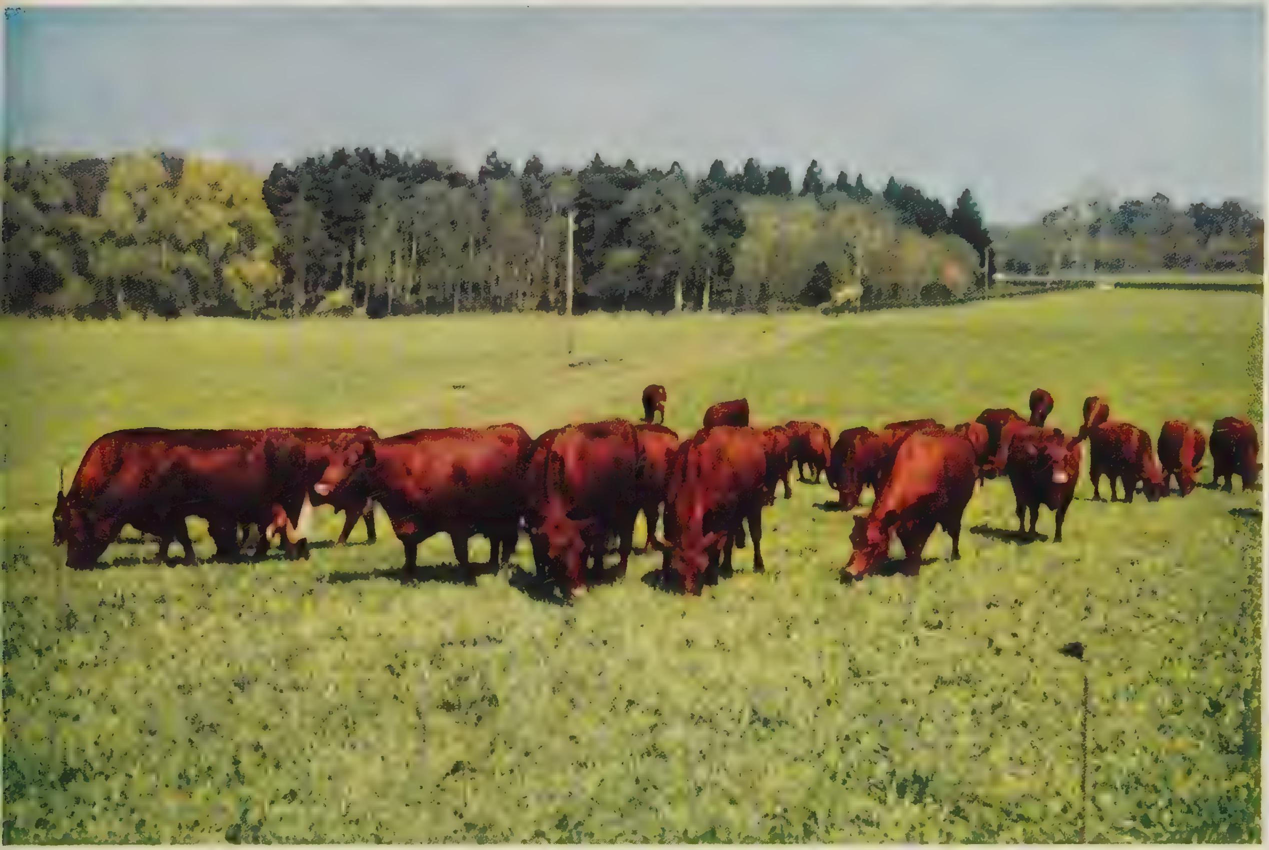


FIG. 1. Red Poll herd on unrestricted early bite.

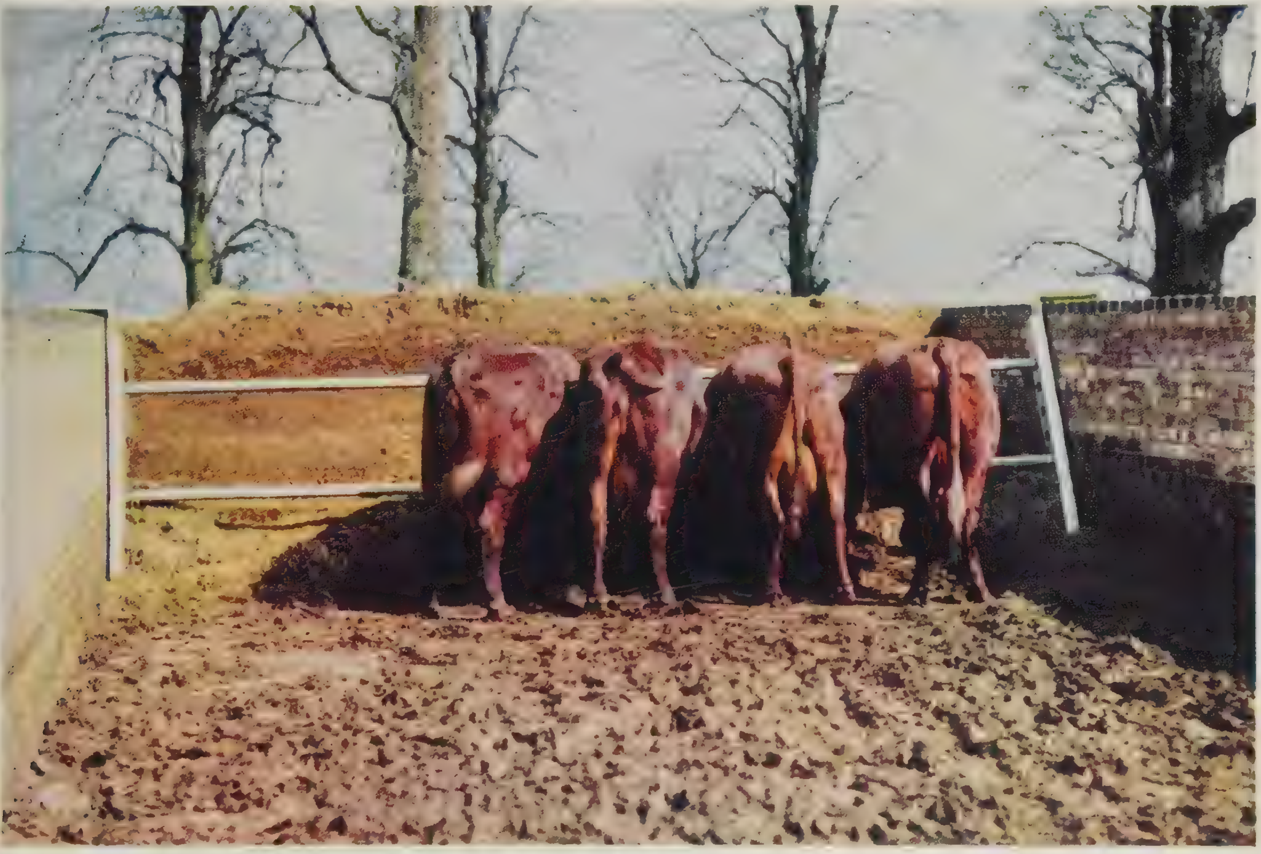


FIG. 2. Self-feeding of dairy cattle from a silage pit. Metal bars restrict the area to be eaten.

strains of grass under environment conditions that permit out-of-season growth and by reserving grass grown in season for grazing off in dormant periods.

It is essential, having provided this out-of-season grass, that it should be used very carefully. Rationed grazing, either by strip grazing with the electric fence or by rotational grazing or some other suitable technique, must be adopted. Recent years have seen considerable advances in grazing methods and grazing efficiency, but under most conditions even the best of the modern systems of grazing will not give good utilisation unless combined with periodic cutting or mowing. It has been found at Jealott's Hill and elsewhere that by continuing strip grazing throughout the season the percentage utilisation decreases with each grazing, whereas when one or more of the grass crops are removed by cutting utilisation is very much better.

However successful the British farmer may be in extending the grazing season, it is unlikely under most conditions that he will be able to provide adequately for his stock on an all-the-year-round basis from grazing alone; unless he is prepared to run the risk of being greatly overstocked during lean periods he is certain to have a surplus of grass at the periods of maximum growth in May to June and again in the autumn.

These circumstances have led to the traditional techniques of grass conservation in which grass surplus to grazing needs at the peak periods of growth is conserved in one form or another for feeding at other periods, mainly in winter. The systems of grass conservation mainly practised in Britain and in most countries are the making of hay, silage and dried grass. Much has been written on these subjects, but conservation plays such an important part in efficient utilisation of grass under British conditions that some discussion of the merits and demerits of the various techniques is essential.

Whatever form of grass conservation be used there is loss of feed nutrients in the process, and it is as well to remind ourselves of the order of these losses by reference to Table IV (after Watson). With the exception of artificially dried grass all conserved products show considerable losses even when made under reasonably good conditions.

With increasing labour and fuel costs dried grass is becoming relatively expensive to make, and its place on the farm must therefore be dictated by economic considerations. Where high-quality dried grass can be made and fed at a lower cost than equivalent nutrients in cereals and purchased concentrates, drying is obviously a good proposition, but in order to provide sufficient flexibility to deal with peaks in production it is usually better to combine grass-drying with silage-making.

TABLE IV

LOSSES IN NUTRITIVE VALUE IN VARIOUS METHODS OF GRASS CONSERVATION

Product	Starch equivalent (%)	Digestible crude protein (%)
Artificially dried	5·0	7·5
Silage with acid or molasses . .	22·5	10·0
Silage without additions . .	35·0	40·0
Hay made on tripod, etc. . .	40·0	25·0
Hay made on the ground . .	45·0	32·5

In spite of the high loss of nutrients in hay- and silage-making it is clear from Table II that average hay or silage will provide starch equivalent at a lower cost than any other product except grazed pasture or perhaps kale. Hay and silage account for over 95% of all grass conserved in Britain, and of this fraction 90% is still in the form of hay—mostly hay made on the ground.

Good hay is an excellent feed and some good hay is essential on almost all stock farms; but haymaking on the scale at present practised in Britain is one of the main reasons for our low general efficiency in grass utilisation. In spite of the fact that an exceptional season in 1955 gave more good hay on British farms than for years past, our average climatic conditions are not compatible with the making of 6 million tons of hay annually (just over 5 million tons dry matter), and in order to increase our efficiency of grass utilisation and reduce the cost of producing livestock products we should be making much less hay and much more silage.

Silage-making is not only a better form of conservation under our conditions, it is also much more compatible with good pasture management than hay-making. Moreover, use of the mower is essential to ensure efficient grazing, and the taking of grass cuts for silage fits in extremely well with either rotational or strip grazing—the most efficient forms of grazing.

Silage-making plays a much less important part in Britain than in most other countries with advanced systems of agriculture, yet our need to make the fullest use of silage is greater than most. We should be making at least 15 million tons (3 million tons dry matter), not $2\frac{1}{2}$ million tons as at present ($\frac{1}{2}$ million tons dry matter). To reach this level in a reasonable time much more progress on silage-making will be required.

Undoubtedly many problems remain to be solved before silage-making can be considered fully efficient. Better-quality silage than that normally made is essential. It must be better protected from the weather, and handling and feeding must be more fully mechanised and simplified. Much more experimental work must be devoted to these ends. If, however, the view is correct that six times the present tonnage of silage is essential for efficient grass utilisation in Britain, there must be a new approach to the whole question of silage-making.

Various methods have been used over the past fifteen years to encourage increased silage-making in Britain, but none so far has been particularly successful. At a time when substantial financial support is being applied to British agriculture—mostly in the form of deficiency payments for products—the question arises as to whether a better return might be obtained by applying some of this in the form of direct financial assistance to silage-making.

A widespread adoption of silage-making on dairy and stock-raising farms in Britain with all that this implies in better grass utilisation would probably go further towards reducing the cost of production of some of our most important livestock products than any other single step.

This emphasis is given to silage-making for unless very much greater progress is achieved in this field efficient grass utilisation in Britain will be greatly impeded. This does not mean that all the problems associated with utilisation of grass by the grazing animal have been solved, although considerable progress has been made in grazing techniques in recent years. In all grassland countries—even in such progressive grassland countries as New Zealand and Holland—various important problems still exist in relation to the efficient utilisation of grass by grazing. The most important are probably those associated with animal health, and a stage has now been reached where solutions to such problems as hypomagnesaemia, bloat, infertility, various allergies and parasitism must be found if further advances in achieving higher output from grassland are not to be delayed.

Another problem which often confronts the grassland farmer is the apparent lower nutritional value of pasture in autumn compared with spring pasture, even though the autumn pasture may be found by chemical analysis to be as high in nutrients, on a dry matter basis, as the spring pasture. Unfortunately there is only a small amount of experimental evidence on this point, and much of this is inconclusive. On one hand it has been shown that autumn grass has a lower sugar content than spring grass and also a lower digestibility; against this, Holmes at the Hannah Dairy Research Institute and Dijkstra in Holland found no difference in milk yields between cows fed on spring- and autumn-dried grass. It is possible that the cold autumn weather increases the energy requirements of the grazing animal and the higher moisture content associated with autumn grass is likely to decrease the intake of dry matter, and it may be that soiling and parasitic infestation at this time of the year lower the efficiency of utilisation.

It is obvious that to make the best use of our pastures much more information is required on all aspects of the problem of grass utilisation. Furthermore, the economic importance of grass in Britain and indeed in the world warrants much greater attention to these problems than has been given hitherto. It is, however, an undisputed fact that, if our present knowledge relating to the production and use of grass were fully exploited, output from British farms could be increased substantially and at relatively low cost. It is unlikely that great progress will be made in lowering the cost of producing animal products in Britain until grass is providing a very much larger proportion of the feed of our ruminant livestock. Efficient grass utilisation is the means to this end.

ACKNOWLEDGMENT

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THE POSITION OF AGRICULTURE IN THE UNITED KINGDOM'S ECONOMY

O. T. W. Price

Since 1939, agriculture in Britain has been transformed in pattern and productivity. A highly mechanised land run on alternate husbandry lines now carries more livestock than ever before, and yields per acre in crops, meat and milk are at record levels. Much more can be done to supply the nation's food. But the needs of industry may conflict, and whether to grow more food at home or buy more from abroad is once again the issue.

It is apparent, even to the casual observer, that agriculture occupies a much more important position in the economic life of the United Kingdom today than it has done within living memory, except during the two world wars. The nature and permanency of this change is of great interest to the nation at large. The role which agriculture now plays and is likely to be asked to play in the decades that follow must have repercussions on developments within the industry. It will influence industries that look to agriculture as a market for their products or depend on it for their raw materials. Last but not least, it will influence the policy which successive governments are likely to pursue. In this article, an attempt is made to appraise the importance of agriculture in the country's economic life, bearing in mind some of these aspects.

AGRICULTURE AND THE GENERAL ECONOMIC STRUCTURE

In order to appreciate the position which agriculture now occupies in the general economy of this country, it is necessary to review, very briefly, changes which have occurred over the last one and a half centuries. One learns with surprise that in the first quarter of the nineteenth century the population of the United Kingdom was about 15½ million, compared with over 50 million today, and that a third of the working population was engaged in agriculture. At this period, only about a seventh of the total food consumed was imported [1]. By the end of the nineteenth century, however, the population had more than doubled but the proportion engaged in agriculture had declined to below 10%. In the meantime the service and manufacturing industries had expanded appreciably, and around 1870 the United Kingdom alone held 40% of the world trade in manufactures. Owing to the unparalleled lead the country enjoyed in manufacturing skill, it was able to import an increasing quantity of materials from abroad for processing and for final re-sale on the world markets. Under these circumstances agriculture declined rapidly, until in the 1930s a little under 6% of the population was engaged in agriculture and two-thirds of our food was imported.

Agriculture underwent major adjustments to meet the changed situation. The real income and standard of living of the urban population rose considerably and their dietary habits altered accordingly. To avoid the full effects of cheap grain imports and to meet the change in demand on the home market, British agriculture became much less dependent on arable farming and expanded its meat and milk production. This was reflected in a reduction in tillage of 5·3 million acres between 1870 and 1938, and an increase in grassland area of 4·2 million acres over the same period. Cattle numbers increased by 50%. The United Kingdom was now facing keen competition on the world markets and was being forced to accept a smaller share of world trade.

With the resumption of international trade after the war, and especially during the last few years, the United Kingdom has occasionally run into serious balance of payments difficulties. This has been due in part to the loss of foreign investments, returns from which helped to pay for imports, in part to the growth of world trade in manufactures and the consequent increase in competition, and in part to a change in the terms of trade in favour of primary products and against manufactured goods.

The terms of trade in recent years have moved in favour of primary products to such an extent that, in 1954, a given quantity of British exports purchased about a fifth of the imports they would have paid for in 1935 or 1938 [2]. This was due in part to the shortage of food arising from the disorganisation of agriculture during the war in many countries. But there is probably a more fundamental reason for this phenomenon. Owing to the shift from agriculture to other industries in some of the chief exporting countries, the amount

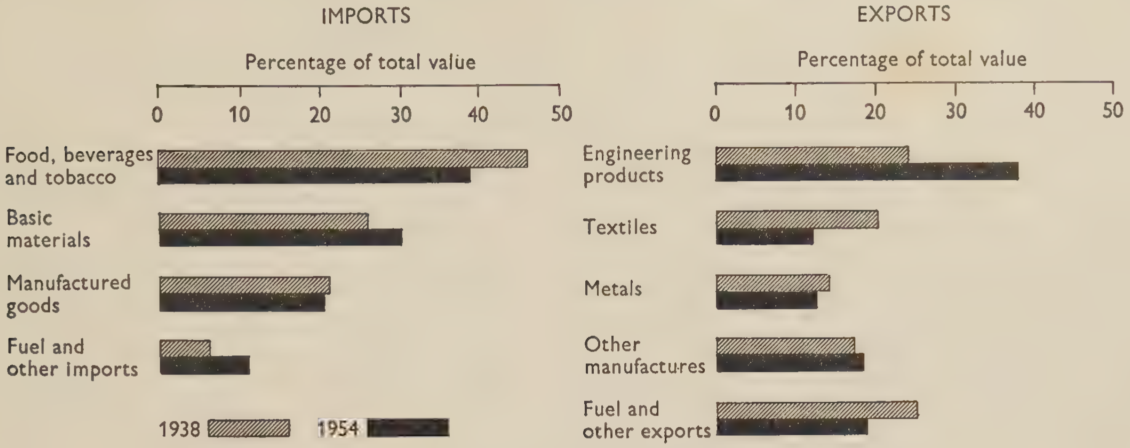

FIG. 1. Composition of United Kingdom Trade by Value, 1938–54 [4].

of food entering world trade has tended to decline. Although the amount of some agricultural products, notably cereals, is larger than pre-war, the supply of livestock products is less. Real incomes and standards of living have been rising in most of the developed countries, and as this feature is associated with an increased consumption of livestock products the demand for meat has lately exceeded the supply. On the other hand the supply of manufacturing goods entering world markets has increased rapidly and is thus tending to push up the demand for raw materials and reduce the price of manufactured products in relation to primary products.

These influences have caused the United Kingdom to find it more and more difficult to export enough to pay for all the raw materials and food it needs. The country has had to reduce its dependence on food imports—about half the food consumed at present is home produced compared with one-third before the war—so that it may purchase raw materials for the manufacturing industries of which over seven-eighths are imported [3]. The change in composition of United Kingdom trade by value between 1938 and 1954 is depicted in Figure 1.

It is noteworthy that whereas food beverages and tobacco represented 47% of total imports in 1938, they represented only 39% in 1954. In contrast, basic materials increased from 26% to 30% of total imports. Despite post-war readjustments, the nation has been faced at intermittent intervals with serious adverse balance of payments with the rest of the world. One such crisis arose in 1955 and was undoubtedly aggravated by the increase in the import of feedingstuffs amounting to at least £55m. a year following de-rationing in 1952.

Grass as a source of feed is considerably cheaper than imported concentrates, and an increase in its efficiency of use and its output could reduce imports of feedingstuffs and possibly some food. The disparity in animal feed costs is so great that British agriculture could, with some confidence, intensify its grassland production, since import feed prices are not likely to fall so drastically or suddenly in the near future as to make such an investment uneconomic.

There is a fair degree of agreement among economic experts that agriculture can and should play a more important role in supplying the country's food than it did pre-war. The major divergence of opinion lies in interpreting future trends in the trading position on the world markets. Some believe that the terms of trade will move slightly more in favour of manufacturing products, while others believe it will deteriorate. A few even contend that another cheap food era such as occurred in the 1930s will reappear, but this is a minority viewpoint and is based more on wishful thinking than objective analysis. Nevertheless, during the last ten years, world output of food has increased by a quarter and already food surpluses are appearing in some countries. This expansion cannot be disregarded, and it could well lead to some deterioration in the terms of trade for agricultural produce. But owing to protective policies, price-support programmes and holding of surplus stocks by some governments, it appears unlikely that food prices relative to other prices will be allowed to fall to the extent they did in the inter-war years.

It is also problematical whether this country can obtain a sufficient share of the world trade in manufactures to pay for its current level of imports, or whether it will price itself out of some world markets and thus be forced to become more self-sufficient in food. To avoid this danger, constant efforts will be needed to curb the inflationary influences of a policy of full employment. Whereas the world trade in manufactures is rising rapidly, the United Kingdom's share of this trade has declined and now stands at about 20% of the total [5] despite increased exports. The United Kingdom must attempt to share more fully in this expansion if its standard of material wellbeing is to increase at the rate which some of its competitors are enjoying.

It would be foolish to predict the answers to these questions since no unanimity exists even among so-called experts in this field of economics as to the trends that British economy may take. It does seem probable, however, that agriculture will not revert to its pre-war position, and the issue to be resolved in the next decade is whether agriculture should continue to produce about half of the nation's food or more.

The belief that agriculture will not be allowed to decline is considerably strengthened by the fact that the major political parties are pledged to a policy of relatively full employment. To follow such a policy, the country is forced to import a large amount of raw materials which must be paid for by foreign earnings, thus limiting the amount available for food importation. It is claimed that the expansion of home agriculture compared with pre-war is now releasing about £400m. for the imports of other products; this would be needed to buy food if agriculture declined to its pre-war position and the terms of trade remained at the present level [6].

Clearly home agriculture cannot be used to save foreign currency at any cost. If capital and other resources invested in the export industries could be applied to purchasing substantially more food on the world markets than the same resources could produce on our farms, it would be an ostrich-like policy to apply them to British agriculture, since the country would be forced to accept a lower standard of living than it could otherwise enjoy. It is extremely difficult to assess fairly the competitive position of home agriculture, but taking into account the quality premium which the British consumer is prepared to pay for fresh home-grown foods, such as beef, it is apparent that our farms can produce these at reasonable prices.

A policy which protects home agriculture against unfair competition is undoubtedly acceptable to the British public but only to the extent that farming efficiency is maintained at a high level. To this end a further shift from tillage to livestock farming may be needed. The level of agricultural production which is considered desirable from the national viewpoint is largely determined at government level, and the volume and type of production required is steered by a system of support prices for about 80% of the output. The government guarantees a minimum price for the products covered and makes up the deficiency between the price realised on the open market and the guaranteed price when this is necessary. These minimum prices are reviewed each year and, as forward price guarantees, allow time for the industry to adjust itself to price changes.

There is a strong likelihood that if the export trade had been expanded for the purpose of purchasing food, and home food production reduced correspondingly, world prices—particularly for livestock products—would have risen steeply. Thus the U.K. has probably followed the wisest policy by expanding its agriculture. A recent analysis undertaken by the Treasury casts further doubt on the wisdom of expanding export trade with food exporting countries and reducing the importance of home agriculture. This analysis suggests that one reason why the U.K. has not expanded its international trade as rapidly as some other countries is because two-thirds of its trade has been with primary producers, and conversely that to expand trade more rapidly will necessitate exchanging goods with manufacturing countries, such as North America and countries of Western Europe. This would entail the exchange of one type of manufactured product for another, rather than for a primary product. Moreover at intermittent intervals our trade with primary producers, such as Australia and New Zealand, has been curtailed by import restrictions; in fact, such restrictions have again recently been introduced by these two countries.

It seems reasonable to conclude that British agriculture may look to the future with quiet optimism, since it will probably be asked to play a more important role in the economy than it did in the first half of this century. Just how important it will become is open to speculation, but increasing efficiency is essential if it is to maintain or improve its position in the British economy.

AGRICULTURE IN THE INTERNAL ECONOMY

The agricultural industry uses over 80% of the land area of this country and it directly employs

1·07 million people or 4·8% of all persons engaged in civilian employment. Lately it provided, together with forestry and fishing, between 5 and 6% of the national income [7]. As the two last by comparison are of minor importance, most of the statistics that follow reflect very largely the position of agriculture.

An analysis undertaken by the Central Statistical Office shows that in 1950 the agricultural group paid £497m. to other industries (Table I). Of this sum, £77m. spent on fertilizers, insecticides, disinfectants, dips and other chemicals represented no less than 8·2% of the total output of the chemical industry and was the highest proportion of output purchased by agriculture from any single industry. The income earned by those engaged in agriculture, forestry and fishing, which totalled £675m., would also create some employment and income in other industries, since an appreciable part of it would be used for personal expenditure by the recipients after paying income taxes and allowing for capital depreciation. The income of farmers alone in 1954, before allowing for taxation and depreciation, amounted to £378m., equal to 2·6% of all personal incomes, compared with only 1·4% in 1938. In recent years farm incomes have attained from 3 to 4% of total personal incomes, but fell by 7% in 1954 owing to a poor harvest. Thus the importance of farmers as purchasers of consumer goods and services has more than doubled since 1938. In addition the group provides raw materials for processing by other industries, which in turn generate income and employment for those engaged in them. In 1950 this contribution amounted to £609m. (Table II).

TABLE I

PURCHASES BY AGRICULTURE, FORESTRY AND FISHING IN 1950 [7]

Purchases from	Value (£m.)
Mining and quarrying	6
Chemicals and allied trades	77
Metals, engineering and vehicles	55
Textiles, leather and clothing	10
Food, drink and tobacco	116
Other manufacturing	41
Building and contracting	30
Gas, electricity and water	4
Other production and trade	105
Imports	53
Total goods and services	497
Income from employment	256
Gross profits, other incomes and rents ..	419
Taxes on expenditure, less subsidies ..	– 44
Total input	1,128

TABLE II

SALES TO OTHER INDUSTRIES BY AGRICULTURE, FORESTRY AND FISHING IN 1950 [7]

Sales to	Value (£m.)
Chemical and allied industries	3
Textiles, leather and clothing	28
Food, drink and tobacco industry	563
Other industries	15
Total	609
Grand total including final buyers and stock appreciation..	1,128

These few statistics can leave little doubt that, directly and indirectly, agriculture creates a substantial amount of employment and economic activity in this country.

To sum up, agriculture occupies a strategic role in the economic well-being of the United Kingdom: it helps to balance trade, and it helps to maintain full employment at home by releasing currency for buying raw materials from abroad, by its purchases of goods and services from other industries, and by the expenditure of personal incomes earned in farming. Agriculture, given the opportunity, can undoubtedly make valuable contributions to the welfare of the nation.

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DEVELOPMENTS IN THE CONTROL OF RED SPIDER MITES

E. C. Edgar

Although modern insecticides have cleared many pests from our crops, they have not only failed against red spider but have actually increased the incidence of these mites by destroying insects that prey upon them. In consequence mite control has become a major concern of the economic entomologist. Research on this subject has occupied the author for some years past, and he describes here how acaricides now being tested at Jealott's Hill offer fresh hope of a solution to this complex problem.

The importance of phytophagous mites as pests of horticultural and agricultural crops has increased considerably in recent years throughout the world. Investigations by many workers into the reasons for this increase in mite populations have shown that by far the greatest contributing factor has been the widespread use of new non-selective pesticides mainly of the chlorinated hydrocarbon or organophosphorus types. These materials destroy mite predators which under some circumstances exert a very high degree of biological control.

A good example of this has occurred with the fruit tree red spider mite *Metatetranychus ulmi*. This pest, almost unknown thirty years ago, is now one of the major pests of top fruits in Europe. Damaging populations were first observed in the early 1920s following the introduction of tar-distillate washes applied to kill the overwintering eggs of such pests as aphids, apple sucker and various moths. Massee and Steer (1929) showed that tar-distillate washes were not toxic to the winter eggs of the mite but lethal to many hibernating predacious insects, including the Athocorid bugs, among which are found some of the chief enemies of the fruit tree red spider mite, attacking it in all its stages. Thus the mites multiplied rapidly in the absence of many of their predators.

The immediate post-war period saw the introduction into the spray programme of materials such as DDT and BHC. These were deadly to most insects, including the predators of red spider, but again had no effect on the mite, which increased alarmingly. About the same time the organophosphorus group of pesticides came into use, and for a while it appeared that parathion might be the answer to the problem. It was toxic to mites as well as insects, and for a few seasons two carefully timed applications prevented the early and most important damage in commercial orchards. Nevertheless a late build-up of mites occurred, and populations at the end of the season were often much higher than those on trees receiving no acaricidal sprays. Collyer (1952) showed that parathion was toxic to all the important predators, and the few beneficial species still surviving or re-establishing after the spring treatments were eliminated by the later parathion sprays. In 1952 the greenhouse red spider mite *Tetranychus telarius*, hitherto of no economic importance on fruit in England, also began to cause damage to apples where parathion had been used for several seasons.

Fungicides were also not without blame. Twenty years ago, Gilliatt (1935) working in Nova Scotia found that predacious mites important in preventing damage by phytophagous species were killed by lime sulphur. Collyer and Kirby (1954) working in Kent reached similar conclusions and showed that the replacement of lime sulphur by new organic fungicides reduced mite populations in spite of the fact that lime sulphur was acaricidal.

To restore the balance between mites and their predators is the ideal, yet it is probably the most difficult way to tackle the problem and unlikely to produce an early solution. At Jealott's Hill we took the view that a quick answer was required and that it might be more fruitful to look for a completely effective acaricide than to modify well-established spray programmes by excluding or restricting the use of many potent insecticides and fungicides. These considerations applied not only to fruit but also to a wide range of crops all over the world.

The seriousness of the problem was quickly recognised by those connected with the entomological side of crop protection, and during the last few years almost half the published work in this field has been concerned with one aspect or another of mite control. New acaricides were rapidly developed, but it soon became obvious that all had their limitations.

In 1949 we intensified our search for improved acaricides, and over 2500 compounds were tested during the following two years. These tests were designed to measure the activity of experimental compounds against that of a standard acaricide, normally parathion. Contact, residual, ovicidal, systemic and in some cases fumigant action of the chemicals were examined.

The life history of plant-feeding mites is very different from that of insects pests and has a considerable bearing on the properties required by an ideal acaricide. Most of these mites behave similarly, and the fruit tree red spider *Metatetranychus ulmi* is typical. The mite overwinters as eggs deposited on the twigs and branches. These eggs hatch from April to June, and the immature mites feed mainly on the under sides of the leaves, moulting several times before becoming adult. The adult mite lays summer eggs which normally hatch in a few days, and the life cycle is repeated six or seven times during the summer before winter eggs are laid on the wood in early autumn. Owing to the number of generations, very high populations of over 100 mites per leaf can build up in the absence of any control. Damage to the trees is caused by the mites feeding on the cell contents of the leaves, which in severe attacks assume a typical bronze colour and fall prematurely. Many mites do not have a winter egg stage and either hibernate as females or remain active all the year round.

Because populations of eggs, larvae, nymphs and adults occur at the same time, acaricides must either be toxic to all stages or have good residual toxicity so that a mixed population may be attacked in a susceptible stage over a period and finally eradicated. Residual toxicity is probably the most important property required. In practice it is never possible to get complete cover of all the foliage when spraying, and even if the acaricide is toxic to both eggs and mites, but not persistent, reinfestation is likely from the few mites that always escape the direct spray. Systemic properties are desirable for the same reasons, and an acaricide should at least be capable of penetrating the leaf so that a spray on the upper side will be toxic to mites underneath. It should be non-toxic to predators so that it can supplement any biological control, not replace it. Resistance of mites to acaricides has usually occurred where biological control has been eliminated and is less likely to appear if predators are present to attack any resistant individuals surviving the spray. The use of some acaricides is limited because they are liable to damage certain plants at effective dosages. The ideal material should be completely safe on all plants. It should be non-poisonous to mammals or be effective at concentrations that are not hazardous to the operator and leave no toxic residues. Toxicity of the concentrate is less important than that of the dilute spray, and it can be safer to apply a low concentration of a highly toxic material than a higher concentration of a less poisonous product.

In 1952, *p*-chlorophenyl *p*-chlorobenzene sulphonate ("Ovotran"), an American discovery, became available in the United Kingdom and fulfilled most of these requirements in a limited field, and for the first time the fruit grower was able to prevent any serious damage to his trees by red spider. It was not toxic to adult mites, but killed the egg and larval stages over a fairly long period, slowly reducing the population as the generation of mites present at the time of spraying died out. Applications to the upper sides of the leaves were absorbed and were toxic to eggs and larvae on the under sides. The chemical had a low mammalian toxicity. Although safe on most fruit there was risk of damage on some other crops, especially cucurbits. High temperatures also appeared to lessen its effectiveness, and control of mites on fruit in hot areas, such as the south of France and Italy, was not adequate. The immediate problem of *M. ulmi* on fruit in this country was largely solved, but there remained many crops in other parts of the world still without fully effective control measures against mites.

In the same year (1952) a compound with outstanding acaricidal activity was discovered at Jealott's Hill. This chemical was O:O′-diethyl-S-β-diethylaminoethyl phosphorothiolate, coded R5158. In tests against the greenhouse red spider mite *Tetranychus telarius* infesting french bean plants, this material appeared to possess major advantages over all acaricides known to us at that time. Water-soluble salts of R5158 can be prepared, and these have similar biological properties to that of the base.

The oxalate, coded R6199, was selected as the most convenient salt. It was seven times as toxic as parathion to the active stages of mite, and when applied as contact sprays on the infested host plant a concentration of 3 p.p.m. gave a complete kill. Residual toxicity was high, and leaves sprayed at 80 and 40 p.p.m. showed little falling off in toxicity over a period of eighteen days.

Absorption by the foliage was rapid, and under laboratory conditions was complete within one hour of application as a dilute aqueous spray on french beans. Deposits on the upper sides of the leaves were toxic to mites feeding on the under surface. Although not ovicidal to any great extent, a spray containing 20 p.p.m. killed all larvae hatching from eggs present at the time of spraying.

These laboratory tests indicated that it should be possible to obtain complete control of a mixed population of mites by a single application at a suitable concentration. A spray at 20 p.p.m. killed all adult mites by contact and over 90% escaping contact but subsequently feeding on sprayed foliage. The same concentration killed all larvae hatching from eggs up to eleven days after spraying. The toxicant was rapidly absorbed by foliage, so that weather would have little effect on its residual toxicity.

Tests against various insects showed R6199 to be relatively non-toxic as a contact and residual poison, and it seemed probable that many insect predators of red spider might be unharmed by sprays at acaricidal concentrations.

There appeared to be only one disadvantage to this material: it was poisonous and an active inhibitor of mammalian acetyl cholinesterase. This was weighed against its outstanding advantages, and it was concluded that, in view of the very low concentrations that appeared necessary for mite control, hazards in its use should certainly be no greater than those of other organophosphorus pesticides, and probably much less. The fact that R6199 is a crystalline water-soluble solid also reduces the danger in handling the concentrated toxicant.

Field trials with R6199 were therefore carried out in 1953 and 1954 against the fruit tree red spider mite in the south of England in comparison with "Ovotran," parathion and "Systox."

In the first trial a young orchard of bush Laxton Superb and Worcester Pearmain apple trees in Essex was used. The trees were lance sprayed on 5th June with R6199 at 40 p.p.m. and parathion at 80 p.p.m. Four plots of 3 × 4 trees were sprayed with each treatment and similar plots left as untreated controls. Mite populations were recorded by the "imprint" method described by Austin and Massee (1947) the day before and at intervals after spraying. The population on ten random leaves from each of the two centre trees of each plot was recorded, giving a total of eighty leaves per treatment. The mite populations are presented graphically in Figures 1 and 2. Results with R6199 were outstanding: the one application at 40 p.p.m. in June gave almost complete control throughout the season. Parathion at double the concentration gave some control, but damage was apparent by the end of August. Populations on the controls reached 65 mites per leaf at the end of the season compared with about one on the R6199 plots. A heavy deposition of winter eggs occurred on the parathion and control plots, but only the occasional egg could be found where R6199 had been applied.

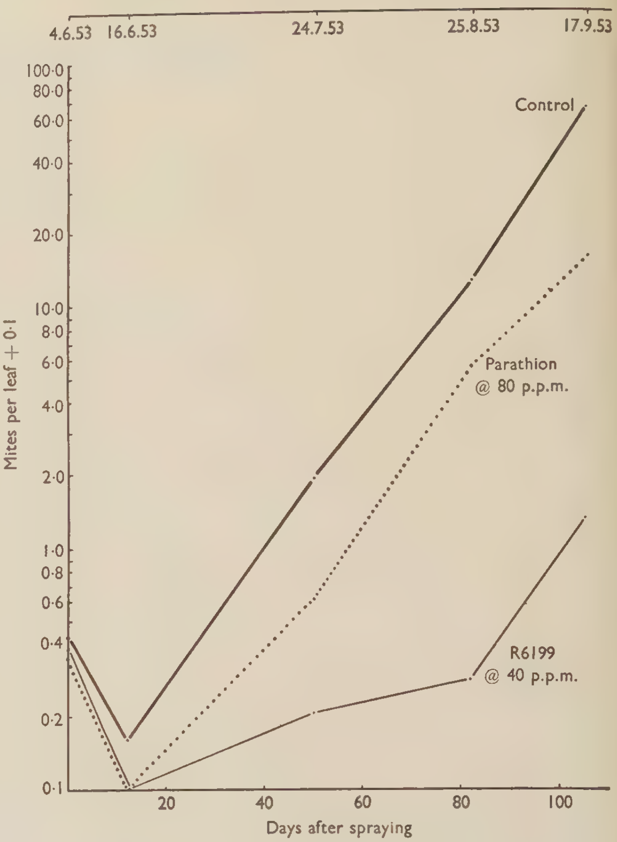

FIG. 1. Trial No. 1. Essex 1953. Mite populations.

In a second trial in Berkshire R6199 was similarly applied on 11th June at 20 and 40 p.p.m. Both concentrations reduced and maintained mite populations at negligible levels throughout the season, whereas 70 mites and eggs per leaf were present on the untreated controls in September and considerable bronzing had occurred.

In these two trials mite populations at the time of spraying were rather low, although a rapid build-up occurred on the controls during August. A more searching test was desirable, and on 6th August 1953 single adjacent Worcester Pearmain

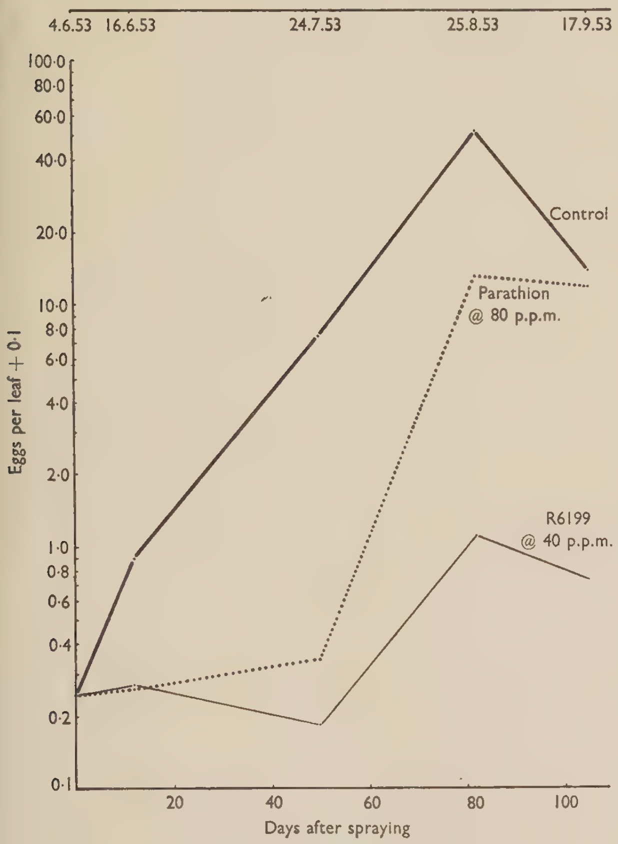

FIG. 2. Trial No. 1. Essex 1953. Egg populations.

trees some 35 years old were sprayed with R6199 at 40, 20 and 10 p.p.m. and with parathion at 80 p.p.m. One unsprayed tree was selected as a control. At the time of spraying all the trees were very severely attacked, having a population of 240 mites and eggs per leaf. The results were spectacular. The mite population on the tree sprayed with R6199 at 40 p.p.m. was reduced from 148 to 0·1 mites per leaf in twelve days, and on 15th September, forty days after spraying, no living mites could be found. This is even more remarkable when one considers the fact that the sprayed tree was closely surrounded by very heavily infested trees from which migration could be expected; but, if this occurred, the residual effects of the treatment killed all the mites reaching the sprayed tree. The degree of control obtained by 20 and 10 p.p.m. was also virtually complete, although the occasional living mite could always be found. Parathion at 80 p.p.m. reduced the population from 103 to 29 mites per leaf in twelve days, but the population built up later and reached 62 per leaf in mid-September. When the trees were examined for winter eggs in October, deposition on the control and parathion-sprayed trees was very heavy and the wood appeared red with eggs, often laid in two or three layers. No fresh eggs could be found on the tree sprayed with R6199 at 40 p.p.m. and very few on those which received 20 and 10 p.p.m. Unfortunately no estimate of the population of mites could be made the following spring, as these trees received a pre-blossom spray with a proprietary summer ovicide.

In 1954 three randomised block trials were laid down and several "growers" trials were carried out. In all cases R6199 gave almost complete control and applied at 20 and 40 p.p.m. was superior to parathion at 80 p.p.m., "Systox" at 125 p.p.m. and "Ovotran" applied once at 500 p.p.m. or twice at 250 p.p.m.

In 1954 and 1955 R6199 effectively controlled various mites on citrus, cotton and other crops, and no failures have yet been reported. The hot summer of 1955 in the U.K. led to serious damage by red spider to fruit even where the new summer ovicides had been used, yet apple trees were well protected by one application in early July of R6199 at 10 p.p.m.

Residues seem unlikely to be important owing to the small amounts of chemical it is necessary to apply, e.g. about 1 oz. per acre on mature fruit. Ripening apples sprayed with 40 p.p.m. R6199 showed less than 0·1 p.p.m. fourteen days later.

Much still remains to be learned about the properties of R6199. The selective toxicity to mites is unexplained and suggests a mode of action different from that of other organophosphorus pesticides; absorption, translocation and fate of the chemical in the plant require investigation; information is needed on the effects on insects, especially beneficial species. Nevertheless R6199 appears the most effective acaricide yet developed, although high mammalian toxicity may preclude its use in some restricted fields.

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DISEASES AND PESTS OF RICE IN JAPAN

G. Watts Padwick

In no country is the technique of rice-growing so advanced as in Japan. Dr. Padwick, author of "Manual of Rice Diseases," reports on the extensive use now being made by the Japanese of chemicals to control rice pests and diseases.

A proper understanding of the pathological problems of rice in Japan demands a little knowledge of geography and agricultural practices.

Japan extends for 1000 miles from north to south over the latitudinal range of 45½° N to 31° N, which is roughly equivalent to that between Milan and a point about 150 miles south of Tripoli. It is a mountainous country, and the arable area (1951) of 5,095,000 hectares is only two-thirds that of the U.K.; but much of it grows two crops of cereals in the year.

Because of the great length from north to south, and because of the opposing influences of the Pacific on one side and the Asian mainland on the other, Japan has a wide climatic range. The southern areas have tropical characteristics, and they grow, besides rice and wheat, such crops as tea, citrus and bamboo. In the north, which has a severe winter, citrus gives place to apples, and bamboos to oaks and other deciduous trees as well as conifers; but wheat, barley and rice are important cereals throughout.

Certain Japanese agricultural practices are inclined to intensify disease and pest problems on rice. As the crop is commonly grown year after year on the same land, the risk of accumulation of pests and of organisms which can cause disease is increased. Frequently a crop of wheat or barley is grown in the winter between two summer crops of rice, leaving little time to prepare the land. The rice seedlings must reach the stage for transplanting the moment the wheat or barley is removed. The crop is heavily fertilized with nitrogen: some 25 lb. per acre is applied to the seed-bed to bring the seedlings along, and transplanted rice receives about 65 lb. of nitrogen per acre. In the north an early-maturing crop is desirable to avoid frosts, and early seedlings are obtained by growing them in beds protected against cold by covering with paper or straw matting or polyvinyl chloride sheets. Both manuring with nitrogen and covering the beds tend to increase susceptibility to certain diseases and pests.

The rice plant is vulnerable to one or another of its natural enemies at every stage in its life, and from the time the seed is sown until the crop is ready for harvest appropriate steps must be taken to minimise damage.

DISEASES

Seed-borne and Soil-borne Diseases

At one time foot-rot or "bakanae" disease, caused by *Gibberella fujikuroi* (Saw.) Wr., was important in Japan. Ito and Kimura (1931) recognised the value of seed dressing for its control. Today 85% of all rice in Japan is grown from seed treated with organomercurial dips. A leading plant pathologist wrote to the author in 1952 saying that the disease had become so uncommon in Japan that specimens were difficult to find in the field. This fact was confirmed during a visit by the writer in 1955.

Nishikado and Miyake (1927) claimed good control of the seedling phase of brown spot of rice, caused by *Helminthosporium oryzae* Breda de Haan, by immersing the seed for 48 hours at about 20° C in a solution of Uspulun, an organomercurial, at the dilution 1 in 800 to 1 in 1200. More recently Nishikado and Nakayama (1943) found natural seedling infection reduced from 60% to 4% as a result of immersing the seed for 12 hours in a 0·5% solution of Uspulun.

Seed treatment is also recommended against certain soil-borne fungi and as a control measure against blast, but there is not much evidence that seed-borne infection with this fungus is of much significance or that the disease can be controlled by seed treatment.

Blast Disease

Blast, caused by *Piricularia oryzae* Cav., is undoubtedly the most important disease of rice in Japan. In the south it occurs in the seed-bed, but in the north only in the paddy fields. Translucent spots appear on the foliage, and these soon coalesce, and ultimately become straw-coloured or grey beneath from masses of spores, often covering the leaves completely. In later stages the stems are attacked, especially at the nodes, causing the heads to fall over sharply and whiten; if the ear has already opened, the rachis and the glumes are attacked and blackened.

Although blast occurs in most rice-growing countries it is to the Japanese and the Indians that we owe most of our knowledge of the factors predisposing the plants to infection. Hemmi and Suzuki (1931) discovered that sowing rice under dry conditions predisposed the seedlings to infection, and Suzuki (1934) related susceptibility in dry soils to a difference in silicification of certain epidermal cells. Although American workers noticed a relationship between newly opened soil and susceptibility of rice to blast, it was in India that Thomas (1930) first demonstrated that increased nitrogen intensified suceptibility. This was confirmed by Suzuki (1935). Several workers tried to relate this to a physical effect on the leaf, but with little success. More than one worker confirmed Suzuki's finding that silica in the epidermal cells was correlated with resistance. Excessive nitrogen and dry seed-beds seem to reduce the silica content and to increase susceptibility to blast, but whether silica actually renders the plants resistant or whether the relationship is fortuitous is a subject of controversy. Some workers claim to have demonstrated a causal relationship, but H. Yoshii (1941) disputes this.

The growing practice of starting off rice seedlings in "hotbeds" brings with it a new problem of increased susceptibility to blast. Investigations are in progress into the nature of the breakdown. Yoshio (1952) records a close correlation between predisposition to disease and the amounts of amino acid and amide nitrogen in the tissue.

Investigations are proceeding in a number of laboratories in Japan on the nature of susceptibility to blast. From the immediate viewpoint, however, the most important work has been on the application of fungicides to the standing crop. Okamoto (1953) found that when used on healthy rice plants copper preparations caused discoloration of the leaves and reduced the weight of grain, whereas the organomercurial mixture had no harmful effect. Nakagawa and Kadoma (1954) found Ceresan mixed with lime in the proportions 1 : 5 and 1 : 8 to be highly effective against the disease, while Bordeaux mixture and other copper preparations were only moderately good.

Thanks to a thorough study of the relationship between weather conditions, spore counts and disease outbreaks, it has been possible to set up a warning system to tell farmers when to dust their crops with organomercurials. Generally speaking, to control blast it is necessary to apply 30–40 kg./ha. (= 27–36 lb./ac.) twice in a season. The dusts contain 0·15–0·25% mercury, and at the prevailing price of 250 yen per kg. retail the cost to the farmer is roughly 5000–6700 yen per hectare, or say £2 to £2 13s. per acre.

In 1954 about 31,000 tons of organomercurial dusts, some 5000 tons of which contained added fixed coppers, were used in Japan, chiefly against blast. It is claimed that no serious ill effects have resulted from their use.

Stem Diseases

The stem rot disease of rice, caused by *Leptosphaeria salvinii* Catt., and the oriental sheath spot, caused by *Corticium sasakii* (Shirai) Matsumoto, are said to have increased in severity in recent years. Possibly this is due to the increased use of nitrogen. Nakagawa and Kadoma (1954) tested various fungicides, including dithane, phygon, ziram, zineb, ferbam and quinone derivatives, against stem rot and found them ineffective, whereas Ceresan–lime mixture was quite satisfactory and Bordeaux mixture moderately so. Some of the mercurial dusts sold for rice are used for controlling these diseases.

Virus Diseases

The most important virus disease of rice is "dwarf." Known in Japan since 1883, it was intensively studied and fully described by Fukushi (1934). It is characterised in the early stages by yellowish-white specks along the veins of newly unfolded leaves, the specks tending later to coalesce, and by marked stunting and excessive tillering. Fukushi (1937) confirmed the finding of an early worker, in 1899, that the leaf hopper *Deltocephalus* (*Inayuma*) *dorsalis* Motsch transmits the disease. The chief vector, however, is *Nephotettix apicalis* Motsch var. *cincticeps* Uhler. Until recently, dwarf was a very destructive disease of rice. The somewhat similar "yellow dwarf" disease of southern Japan likewise causes stunting and excessive tillering, but the leaves display a simple chlorosis and do not show yellowish-white specks. It is likewise transmitted by *N. apicalis* var. *cincticeps*.

Insecticidal dusts are used to control the leaf hoppers which transmit these diseases. Against most hoppers a 0·5% or 1% BHC dust is effective, but not against *Inayuma dorsalis*, for the control of which DDT or parathion is recommended.

Enormous quantities of BHC and parathion have been used on rice in recent years. They amounted in 1954 to over 40,000 tons of dilute dusts. While the great bulk of this was used against stem borers, the dusting of leaf hoppers is also accepted practice. It is reasonable to believe that this may account for the decline of dwarf disease in recent years. The cost of one dusting with 30 kg. of 1% gamma-BHC per acre at present prices is about 11s. for the chemical only.

White Tip

"White tip," described by Yoshii and Yamamoto (1950*a*), in which the tips of the leaves are diseased and bleached, has been known in Kyushu for some years. Its cause, a nematode, was discovered in 1944, and was described by Hazime Yoshii in 1946 under the name *Aphelenchoides oryzae* Yokoo, later recognised as *Aphelenchoides besseyi*. Unlike the destructive Indian nematode disease "Ufra," white tip is seed-borne. Various control measures have been tried. Yamada and Shiomi (1950) found steeping in hot water (52° C) for 10 minutes after pre-soaking in Uspulun solution an effective measure. After extensive experiments Yoshii and Yamamoto (1950*b*) recommended soaking the seed in cold water below 20° C for 16–20 hours, then immersing in hot water at 51° C (with a range of 50–52° C) for 7 minutes (with a range of 5–10 minutes), as a safe and effective method of control.

PESTS

Rice Stem Borer

The two common stem borers—the rice stem borer *Chilo simplex* Butler, and the paddy borer *Schoenobius incertellus* Walker—occur in Japan, but the latter is restricted to the warmer parts. *Chilo simplex* is recognised as the worst insect pest of rice in Japan. In central Japan there are two generations in a year; in the south, three; in Hokkaido, one. In the south, burning stubble to destroy larvae, catching moths in the field with the aid of lamps, and liberating parasites have helped to reduce damage but have not eliminated it; in the north, stubble burning is impossible, as the land is covered with snow soon after harvest; but blue fluorescent lamps are used to catch moths emerging from piles of stored straw.

Experiments carried out in Hokkaido since 1951 are described by Kuwayama (1954). In early tests BHC proved to be the best chemical available, with DDT second and chlordane almost ineffective. Later, parathion emulsion proved highly effective, the dust less so, and BHC inferior to either, though by no means ineffective. Suenaga and Hashizume (1953) in Kyushu have demonstrated a considerable systemic effect from parathion, the first-brood larvae being killed up to three weeks after boring by spraying with a 0·0155% parathion emulsion at 117 gallons per acre or dusting with a 0·5% parathion dust at 27 lb. per acre.

Today, although parathion sprays are used to some extent, the more popular treatment is two applications of 1·5% parathion dust, that for the first brood being at 18 lb. per acre and for the second brood 36–45 lb. per acre. The spray, sold as a 46·6% concentrate, is applied at 1 : 2000 dilution at 60–75 gallons per acre for the first-generation larvae, and a 1 : 1000 dilution at 200 gallons per acre for the second generation. Over 16,000 tons of parathion dust were used on rice in 1954. The amount of liquid used was smaller—it is impossible to say just how much.

As an alternative to parathion a 1% gamma-BHC dust is applied at 27 lb. per acre to prevent the first brood of rice stem borers from entering the stems. If larvae have already penetrated the stem a 3% gamma-BHC dust is applied at 27–36 lb. per acre. Against second-brood larvae a 1–3% gamma-BHC dust is applied at 36 lb. per acre, or a wettable powder may be used. BHC dusts amounting to over 24,000 tons were sold for use on rice in Japan in 1954.

The farmer will spend considerable sums of money to kill borers. The 1·5% parathion dust costs him about 130 yen per kg., or for 65 kg. (enough to treat 1 hectare) 8450 yen, or £3 7s. 5d. per acre. Using a 1% gamma-BHC dust at 30 kg. per hectare for the first brood and 40 kg. for the second brood at a price of 48 yen per kg., the cost amounts to 3360 yen per hectare, or £1 6s. 7d. per acre, exclusive of application costs; the higher concentration which must often be used for stem borers is considerably more expensive.

Leaf Hoppers

Of the other pests of rice the leaf hoppers are among the most important, because they not only themselves cause damage but also transmit virus diseases.

The white-backed plant hopper (*Sogata furcifera* Horvath) and the brown plant hopper (*Nilapervata lugens* Stål) cause heavy losses throughout Japan. There are three, sometimes more, generations of each in a year. They are controlled by 0·5% or 1% gamma-BHC or 2·5% DDT dust. BHC is ineffective against the green rice leaf hopper

(*Nephotettix apicalis* var. *cincticeps* Uhler), but DDT is recommended.

Parathion is effective against some of, if not all the rice leaf hoppers. Suenaga and Hashizume (1953) found a 0·1% emulsion and a 1·5% dust of parathion effective for at least ten days against *S. furcifera*, *N. lugens* and *N. apicalis cincticeps*.

DISCUSSION

The reasons for the extensive use of chemicals to control diseases and pests of rice in Japan deserve examination.

Japan is obliged to import food but is seriously short of foreign exchange. Though bread is growing in popularity, rice is still the staple food. The present price of rice is about £66 per ton. This encourages the farmer to use every means to increase his crop. As the average yield of unpolished rise is 2300 lb., the crop is worth roughly £70 per acre. It receives heavy dressings of fertilizers, worth perhaps £7 per acre.

The cost of seed treatment is slight. The dust for control of blast, however, may cost £2 to £3 per acre, while parathion for prevention of stem borers may amount to £3 to £4 per acre for a dust or as much as £6 per acre for a spray, which is more effective. A 3% gamma-BHC dust for control of borers would be cheaper than parathion dust but somewhat less effective. The 1% gamma-BHC dust used for control of some other pests costs about £1 7s. per acre. These figures exclude the cost of applying the chemicals.

It will be seen that the chemicals for control of an average outbreak of blast would cost only 5% of the value of an average crop. Undoubtedly losses to a much greater value than this are often prevented by mercurial dust treatment. Average losses due to stem borers before the use of parathion are estimated to have been about 15%, which at present prices would be about £10 10s., considerably exceeding the most expensive control measures. Evidently the chemical control even of average outbreaks of pests and diseases is profitable.

Economics is the most important thing which has encouraged the use of chemicals on the rice crop in Japan. It is not, however, the only factor. The Japanese are a hard-working, intelligent and well-read people, receptive to new ideas. The farmers are keen to get information from the advisory staff of the government, and the extension services are well organised.

When new methods of crop culture are introduced, new problems must be expected. The Japanese, faced with an increased predisposition of rice to diseases and pests because of the use of abundant nitrogen and for other reasons, have taken steps to deal with the new problems arising.

Other Asian countries will some day again be faced with food shortages and will have to intensify rice culture. The starting point will be better use of water, but with real pressure on food supplies all possible means of increasing yield will have to be adopted, including the control of diseases and pests.

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THE USES OF PLANT GROWTH SUBSTANCES

W. G. Templeman

Few developments in applied biology have been of such immense benefit to the farming world as those arising from the study of plant growth substances. A hundred million acres of clean crops bear annual witness to their value and popularity as selective weed-killers, and it is appropriate that Dr. Templeman, who discovered the first of these, should review the uses that have so far been found for the synthetic growth regulators.

It is becoming increasingly difficult to define a plant growth regulator. Audus (1953) used phytohormone synonymously with plant growth-regulating substance to mean "an organic compound which, in extremely low concentrations, regulates the growth of the plant in one or more of its several aspects." That definition will be used here provided it is recognised that the examination of a large number of substances has revealed a wide concentration range over which a particular effect may be induced. In other words, a growth regulation may be brought about by compound A at one concentration and the identical effect by compound B at many times less or more than the concentration necessary of compound A. The amount of emphasis which can be placed on concentration in this definition has lessened.

Thousands of chemicals have been synthesised and tested for effectiveness on one or more aspects of growth regulation. Active compounds now find established uses for the stimulation of the rooting of cuttings, the prevention of sprouting of tubers, the induction of parthenocarpic fruit formation, prevention of preharvest fruit drop and selective weed control. In practical agricultural importance the herbicidal use far outweighs all the others. Defoliation, fruit ripening, blossom thinning and growth control as distinct from plant killing are all uses for which plant growth regulators are being examined on a commercial scale; they will not be dealt with in this paper. Attention will be restricted to established uses in horticulture and agriculture.

ROOTING OF CUTTINGS

Methods of vegetative reproduction are of great importance in raising new plants of many economically important species. Some of these depend on subjecting some detached portion of the parent plant to conditions which promote root initiation and development resulting in a new complete plant. Shoot, root and leaf cuttings are frequently used. Miscellaneous chemicals have been employed over many years to assist the rooting of cuttings, but mostly only small and indefinite results were achieved. It was in this field that synthetic plant growth regulators were first adopted in commercial practice. Cooper (1935) was the first to show that β-indolylacetic acid in lanoline paste stimulated the rooting of lemon cuttings. It is interesting to note that applications were at first apical, as it was thought this simulated natural auxin source and transport conditions. Basal applications were soon shown to be equally effective and considerably more convenient.

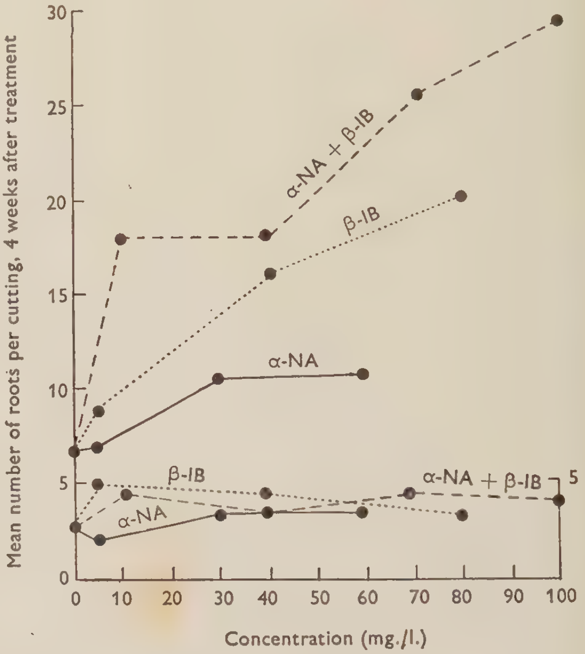

FIG. 1. Cacao cuttings: effect of growth regulators on rooting. α-NA = α-naphthylacetic acid; β-IB = β-indolylbutyric acid. (From data of Evans, H., 1951, *Trop. Agric.*, **28**, 147.)

In the next year or two many chemicals were examined and it was quickly established that β-indolylbutyric acid and α-naphthylacetic acid were very suitable (Figure 4). These two have remained the most popular since their early use, and only recently have the halogen-substituted phenoxy propionic (e.g α-(2:4:5-trichlorophenoxy) propionic acid) and *n*-butyric acids been shown to be highly active root initiators. Type and form of rooting vary somewhat with small changes in molecular structure, and it is reasonable to expect that some specificity between compound and plant will be found.

The normal methods of treatment of the cuttings are by application of the chemical in a lanoline paste to the basal end, by standing the cuttings with their basal ends in a dilute solution for a period of several hours or by momentarily dipping the basal ends in either a concentrated solution or dust. In practice, the lanoline paste method is cumbersome and little used, and much of the commercial usage is of the concentrated liquids or dusts.

A wide range of plant species has been tested for rooting response to plant growth regulators, and for details the lists prepared by various workers (e.g. Pearse, 1948; Audus, 1953) may be consulted.

Use of these compounds is made in commercial nurseries, and cocoa and rubber are two of the most important crop plants where this method has proved particularly useful. Figure 1 (Evans, 1951) indicates the type of results which are obtained.

INHIBITION OF BUD GROWTH

It has long been known that an active terminal bud of a shoot possesses the power of inhibiting the growth of lateral buds, and Guthrie (1938) showed that α-naphthylacetic acid as its potassium salt (and later in ester form) prevented the sprouting of potatoes in store. Methyl α-naphthylacetate has found wide use for this purpose. 2:3:5:6-tetrachloronitrobenzene (Brown, 1947) is an active sprout depressant but not so effective as isopropyl *N*-phenylcarbamate (IPC) which applied at about 0·0027% on the tubers effectively inhibits sprouting for several months (Rakitin and Troyan, 1949; Rhodes, Sexton, Spencer and Templeman, 1950; Rhodes, Spencer, Templeman and Sexton, 1951). Isopropyl *N*-(3-chlorophenyl) carbamate is even more effective (Marth and Schultz, 1952). Unfortunately IPC also reduces the tubers' ability to develop suberised tissue to seal off invading hyphae of *Oospora pustulans* (skin spot) (Dillon Weston, 1952).

The results of an Australian experiment with IPC in preventing potato sprouting (Downie, 1952) are given in Table I.

With both α-naphthylacetic and chlorinated phenoxyacetic esters and the phenylcarbamates it is necessary to apply the active chemical as an external spray or dust to the harvested tubers. Maleic hydrazide, however, has shown marked sprout-inhibiting properties on the bulbs during storage when sprayed on to the foliage of onions several weeks prior to harvesting (Witwer, Sharma, Weller and Sell, 1950) and has also proved effective on potatoes (Zukel, 1950). The results so far obtained have not been as good as those obtained by direct application of the phenylcarbamates to the tubers and it remains to be seen whether an effective sprout inhibitor can be combined with an effective haulm-destroying spray so that the two requirements may be achieved by one operation.

It has been suggested that the bud-inhibiting properties of some of these plant growth regulators should be used for such purposes as delaying the bud opening of fruit trees until the danger of frost is past and for preventing sucker growth of tobacco. The results of experiments so far have not permitted recommendations being made for these purposes.

FRUIT PRODUCTION

Three main uses for plant growth regulators in commercial fruit production have been found: (i) for the initiation of parthenocarpic fruit production, (ii) for the prevention of the drop of immature fruit, and (iii) a specialised application for the acceleration of flowering of pineapples.

The influence of pollen extracts on fruit development has been known for many years, and now many plant growth regulators have proved capable of inducing parthenocarpic development (see Audus, 1953). Various indolyl, naphthyl and substituted phenoxyacetic acids are active, and effective applications have been made as aqueous solutions, dispersions, aerosols and vapours (of the volatile esters) to flowers at the appropriate stage of growth. There are minor differences in response (due to differences in fruit shape, nature of flesh and thickness of skin) from different compounds, and some evidence that best results are obtained by using mixtures.

As in all the applications of plant growth regulators there are wide differences in the fruit production stimulated for different plant species. Tomatoes are notable in their response, but excellent results have been achieved with figs

TABLE I

EFFECT OF IPC ON POTATO SPROUTING 5 MONTHS AFTER TREATMENT

Variety	Control			IPC 2% dust at 3 lb./ton tubers		
	Tuber weight lost (oz.)	Weight of sprouts (oz.)	Total weight lost (%)	Tuber weight lost (oz.)	Weight of sprouts (oz.)	Total weight lost (%)
Green Mountain	24	18	26	15	0	9
Katahdin	22	23	28	13	0	8
Up-to-date	20	12	20	15	0	9
Late Carman	20	26	29	17	Tr	11
Exton	20	10	19	14	0	9
Sequoia	19	10	18	13	0	8
Mean	21	16	23	15	0	9

Original weight of tubers = 10 lb. After Downie, W. A. (1952). *J. Dep. Agric. Vict.*, **50**, 61.

(Smyrna and Calimyrna varieties), apples, pears, plums and strawberries, and several others. This practice has shown up to advantage where pollination is difficult or seedless fruits are desirable. It has been particularly valuable for the tomato under conditions where a good early fruit set is achieved only with difficulty owing mainly to unfavourable seasonal variations in the weather.

As an example of the type of result which may be obtained, two experiments carried out in 1948 and reported by Wain (1950) may be quoted in Table II.

TABLE II

EFFECT OF GROWTH REGULATORS ON FRUIT SET

Treatment	Canterbury (oz. per 240 plants)	Wye (oz. per 192 plants)
OCP	2999	2889
BNA	2958	2214
BNP	3049	2501
Mixture	3643	2682
Control	2292	644
Spraying dates	1st July	29th July

Total yield of tomato fruit from bottom trusses, 1948 Variety "Harbinger." Grown outdoors. OCP = α-(2-chlorophenoxy) propionic acid (40 p.p.m. of acid); BNA = β-naphthoxyacetic acid (60 p.p.m. of acid); BNP = α-(β′-naphthoxy) propionic acid (100 p.p.m. of acid); mixture = BNA (40 p.p.m. of acid) plus 4-chlorophenoxyacetic acid (10 p.p.m. of acid). From Wain, R. L. (1950). *J. hort. Sci.*, **25**, 249.

All the above were used as methylglucamine salts and each spray contained 0·004% wetting agent.

It must, however, be emphasised that general American experience with tomatoes is that earliness may be promoted but total yield is little influenced by the use of hormone sprays.

The prevention of premature fruit drop by the use of growth-regulating chemicals is now widely used for various apple varieties. For over twenty years it has been thought that auxins play a part in abscission, and La Rue (1936) prevented leaf fall by the use of several synthetic compounds. In studies on parthenocarpy Gardner and Marth (1937) found that leaf and berry fall in holly could be prevented and, soon after, these workers and Batjer (1939) found that the preharvest drop of apples could be stopped. Close relationships between auxin production by the seed and the amount of fruit drop has been shown by Luckwill (1948). Low auxin content leads to abscission.

There is again varietal and species variation to growth regulator treatment, but the pome and citrus fruits give best response; apples, and to a less extent pears, are the commercial crops most widely sprayed. α-Naphthylacetic acid at a spray concentration of around 10 p.p.m. is the most popular treatment, but a number of other compounds over a range of concentrations are known to be effective. The chief practical difficulty is to know when to spray, and this can only be calculated by prior knowledge of when a particular variety is likely to drop fruit and the average

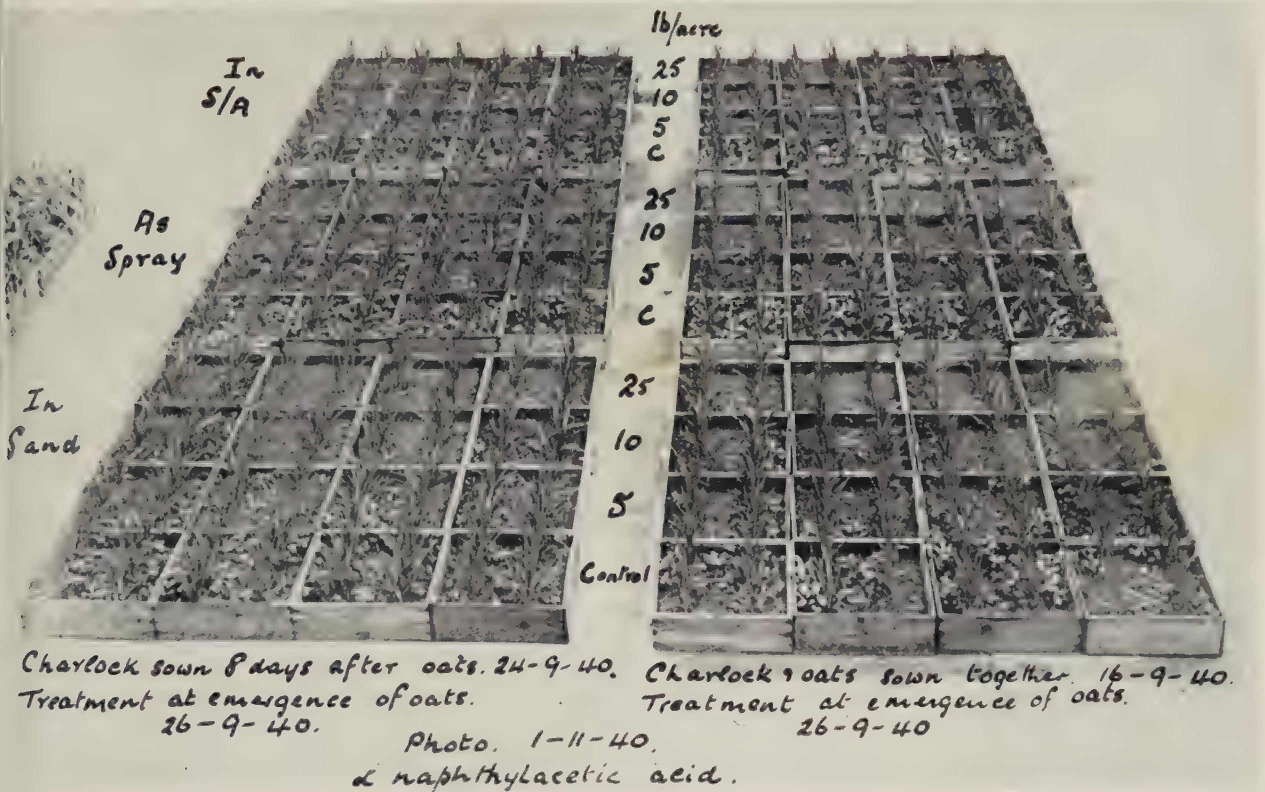
lb/acre
In S/A
As Spray
In Sand
25
10
5
C
25
10
5
C
25
10
5
Control
Charlock sown 8 days after oats. 24-9-40.
Treatment at emergence of oats.
26-9-40.
Charlock & oats sown together. 16-9-40.
Treatment at emergence of oats.
26-9-40
Photo. 1-11-40.
α naphthylacetic acid.

FIG. 2. This photograph, taken at Jealott's Hill in November 1940, is of historic interest. It shows one of the experiments in which the selective weedkilling action of a synthetic plant growth regulator was demonstrated for the first time.

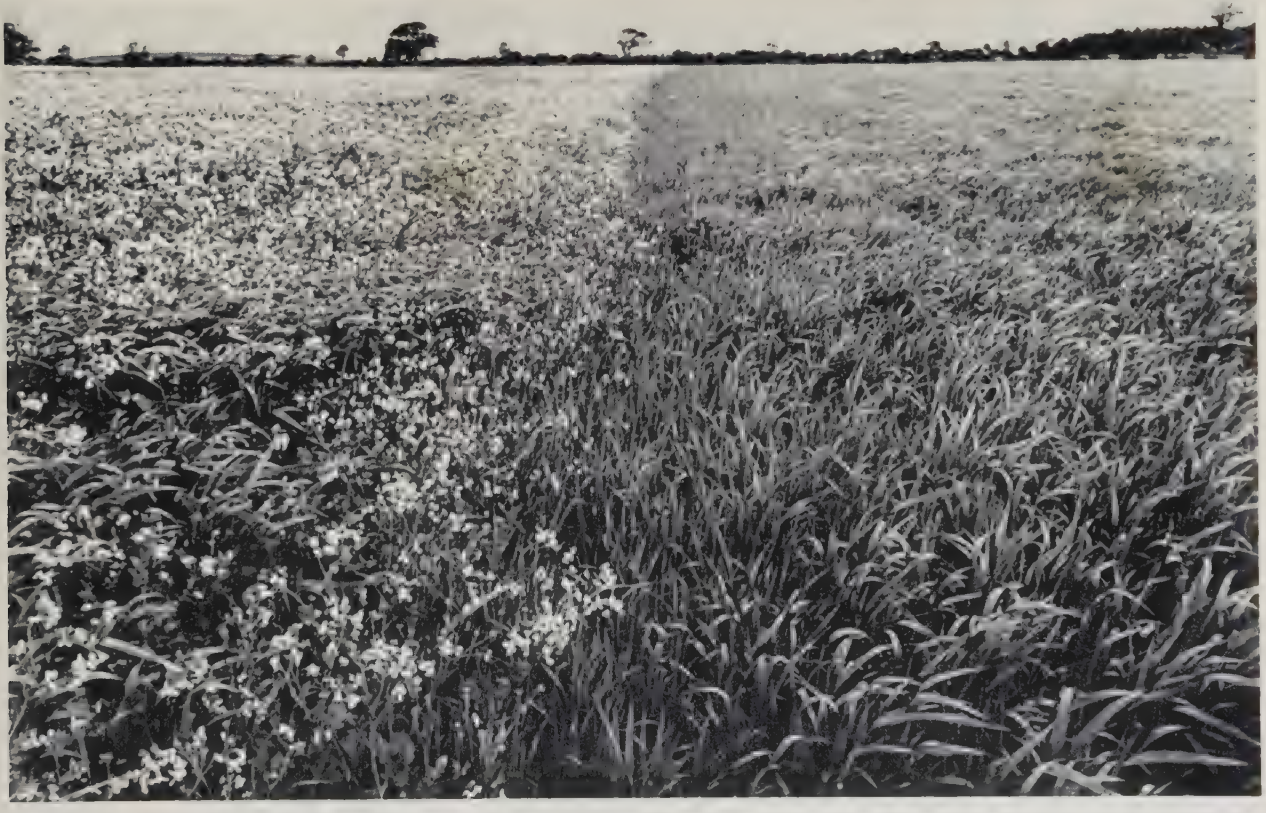

FIG. 3. Selective herbicidal action. White charlock is eradicated from oats (right) by treatment with sodium 2-methyl-4-chlorophenoxyacetate at 2 lb./acre. The left half of the field was untreated.

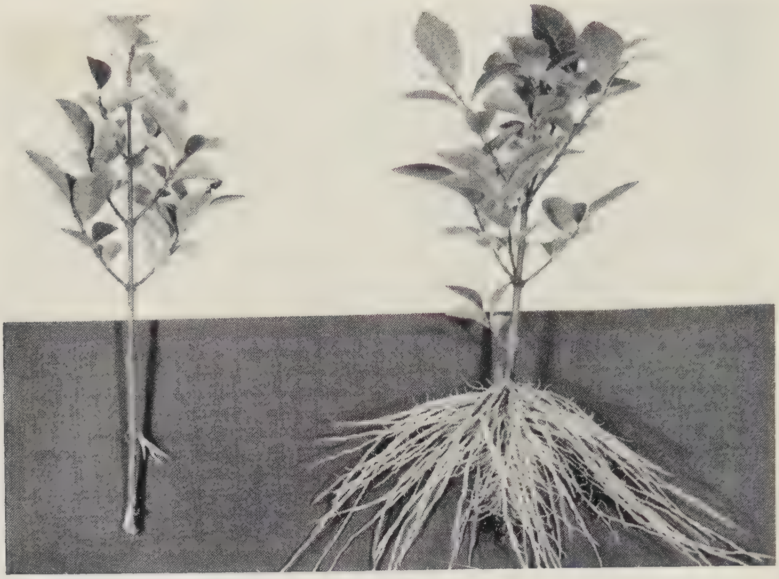

FIG. 4. Stimulation of rooting in cuttings. The effect on privet is shown ten weeks after treatment with sodium α-naphthylacetate (right), compared with an untreated cutting (left).

period of effectiveness of a given compound for it. Sprays are almost universally used, but various dust and injection methods have been proposed as have combinations with various fungicides and insecticides.

In connection with pineapple culture van Overbeek (1951) states that the date of harvest in Hawaii and South America can be accurately regulated by a single application of about 1 oz./acre of α-naphthylacetic acid at a total cost of about 5 U.S. dollars per acre. Pineapple varieties vary greatly in the time taken to reach the flowering stage and under natural conditions this is of somewhat spasmodic occurrence. Spraying the plants with a solution of α-naphthylacetic acid (of 5–10 p.p.m. concentration) initiates flower primordia and allows a cropping programme to be laid down. Harvesting dates can be arranged and fruit gathering can rotate around the fields of the farm.

WEED CONTROL

Until the discovery of the so-called hormone weedkillers during the second world war the most widely used selective weedkillers were copper salts, dilute sulphuric acid and 3:5-dinitro-*o*-cresol as sprays and kainit and calcium cyanamide as dusts. With the advent of the growth regulators as herbicides the usage of non-hormone weedkillers has not diminished but has increased considerably. The scale on which the chlorinated phenoxyacetic acids are used can be estimated from available data. It is known that about 20,000 tons of 2:4-D and MCP acids were manufactured in 1952. If an average rate of application was $\frac{1}{2}$ lb./acre then the weedkillers were used on approximately 80 million acres.

The discovery of the selective herbicidal action of growth regulators was made at several separate places during the second world war and, owing to the secrecy regulations then in force, publication of the British results was very much delayed.

First, at Jealott's Hill Research Station, as a consequence of previous experiments with β-indolylacetic acid and α-naphthylacetic acid on cuttings and whole plants, it was found in the autumn of 1940 that 25 lb./acre of the latter compound killed yellow charlock (*Brassica sinapis*) without harming oats when the two were sown together and independent of whether the application was made before or after the emergence of the seedlings (Figure 2). Joint chemical and biological work yielded 2-methyl-4-chlorophenoxyacetic acid in 1941 and 2:4-dichlorophenoxyacetic acid in 1942; both proved effective weedkillers in cereals in pot or box scale tests at about 1 lb./acre (Sexton, Slade and Templeman, 1945; Slade, Templeman and Sexton, 1945).

Secondly, at Rothamsted resulting from work which began in 1941 (as a result of earlier work on the factors causing the curling of legume root hairs) it was found that β-indolylacetic acid and α-naphthylacetic acid were toxic to seedlings at low concentrations and, when looking for a compound with greater persistence in the soil, 2:4-dichlorophenoxyacetic acid was shown (in experiments which commenced in 1942) to be more toxic to sugar beet and red clover than to wheat (Nutman, Thornton and Quastel, 1945).

The results of the independent work at these two stations became available to each of them when the two sets of conclusions were reported to the Agricultural Research Council in November 1942. From that date onwards many field trials were undertaken by the Agricultural Research Council (Blackman, 1945; Blackman and Roberts, 1950), the Norfolk War Agricultural Executive Committee (Hudson, 1946) and Imperial Chemical Industries Ltd. (Templeman and Halliday, 1950).

Thirdly, in the U.S.A. in 1942 the chlorinated phenoxyacetic acids were reported as growth regulators, but *not* as herbicides, by Lontz (1943; Jones, 1953) and by Zimmerman and Hitchcock (1942). In a paper published in 1944 Marth and Mitchell stated that in a private communication in 1941 E. J. Kraus had suggested that plant growth regulators might be useful as herbicides. Jones (1945, 1953) has reported that he found 2:4-dichlorophenoxyacetic acid to have herbicidal properties in 1942, and in publications from the U.S.D.A. Station at Beltsville in 1944 (Mitchell and Hamner, 1944; Marth and Mitchell, 1944) 2:4-dichlorophenoxyacetic acid was shown to have *selective* herbicidal activity. There was tremendous development in research and use in the U.S.A. following these publications. When the American results appeared in print, the conclusions from the English work were also published (Slade *et al.*, 1945; Nutman *et al.*, 1945; Blackman, 1945).

The principal chemicals are 2:4-dichlorophenoxyacetic acid (2:4-D), 2-methyl-4-chlorophenoxyacetic acid (MCP) and 2:4:5-trichlorophenoxyacetic acid (2:4:5-T). The latter compound was first described as a herbicide by Jones (1945, 1953) and Hamner and Tukey (1944). Especially in the U.S.A., a wide range of derivatives of these acids are in use such as sodium and alkanolamine salts and the alkyl and so-called "low volatile" esters. Commercial products are often formulated with varying quantities of solvents, emulsifying or dispersing agents, wetters or spreaders and sometimes contain varying quantities of impurities, some of which may be closely related to the active principles. It is interesting that the intensive research of the last 10 years has not produced any compounds more active in this field than the derivatives or close relatives of 2:4-D, MCP and 2:4:5-T.

By far the larger amount of these weedkillers is applied as an aqueous spray, although dusts are still used in some places. To reduce the volume of water required, so-called "low-volume" sprayers which apply from about 5 to 20 gal./acre were introduced. Many of these machines are of the cheap and simple tractor-mounted type and since they were introduced for weed control purposes, uses for other plant protection agents have expanded continuously. Aerial spraying for herbicide application has also developed considerably.

The established uses for hormone weedkillers are for weed control in cereals (including maize and rice), linseed and grassland. Weed species vary widely in their susceptibility, but yellow charlock or mustard (*Sinapis arvensis*), one of the world's most widely distributed annual weeds of cereals, and white charlock (*Raphanus raphanistrum*) are very easily eradicated by 2:4-D and MCP (Figure 3). Since they are readily translocated they have proved particularly valuable for the control of some perennial weeds; they effectively kill water hyacinth (*Eichhornia crassipes*), one of the most pernicious floating aquatic weeds of inland waterways in warm climates. 2:4:5-T is now widely used for the control of woody plants, brush and scrub. Many weeds are dwarfed and restricted in growth by doses which eliminate susceptible species and are thus much subdued as competitors for water and nutrients, but it must be made clear that there are many weeds which are very resistant to these weedkillers.

The last decade of research on weedkillers in cereals has added much to our knowledge of the factors which influence both degree of weed control attained and any effect upon the crop. Blackman and Roberts (1950) found that an average increase in yield of grain (winter wheat, spring oats and barley) as a result of annual weed control from experiments carried out between 1943 and 1947 was of the order of 23%. In some of the great maize-growing areas of the world this crop is very sensitive to weed competition and the value of weed control is proportionately greater.

These weedkillers are equally effective against many important weeds of pastures and rangelands, but it is here more difficult to make a quantitative assessment of the benefit which accrues. The use of any increased quantities of herbage is affected by many factors and there are many deficiencies in the available experimental techniques for this type of work. An added complication is that the economics of grassland farming in many parts of the world are unfavourable to the use of any weedkiller at present prices. For these reasons only a limited amount of experimental data is available, and this is chiefly concerned with the immediate benefit in herbage yield, such, for example, as shown in the results of the following trials (Halliday and Templeman, 1951) carried out in 1946–7 (Table III).

Some plant growth regulators are potent mitotic poisons, and of these the phenylcarbamates have achieved most agricultural usage. Isopropyl *N*-phenylcarbamate (IPC) was found in 1941 at Jealott's Hill (Templeman and Sexton, 1945; Sexton and Templeman, 1946) to be a very potent inhibitor of germination and early seedling growth of grasses and cereals. From a series of field experiments in 1941–2 which involved about 10,000 plots it was concluded that about 3 lb./acre of this chemical applied just before, during or within a few weeks after sowing obliterated crops of winter and spring cereals. Applications at later stages of growth if the weather conditions were suitable arrested development and eventually killed the plants. Many broad-leaved plants were unaffected by these dressings but some dicotyledons, for example many *Polygonum* sp., chickweed (*Stellaria media*) and buckwheat (*Fagopyrum esculentum*), are sensitive.

TABLE III

CONTROL OF BUTTERCUP (*Ranunculus* sp.)

	MCP (lb./acre)		
	0	2	4
Total useful herbage ..	17·6	22·8	22·4
Buttercups	8·3	2·3	1·7
Clover	2·4	1·8	0·5

Average yields (cwt. dry matter/acre) from eight trials. MCP applied: autumn 1946. Hay cuts: early summer 1947.

Isopropyl *N*-(3-chlorophenyl) carbamate (Cl IPC) was found (Freed, 1949; Witman and Newton, 1951) to have greater persistence in soil than IPC and is widely used for the control of annual grasses and some other weeds in cotton when used as a pre-emergence spray. IPC itself gives effective control of wild oats (*Avena fatua*) in peas in the Pacific north-west of the U.S.A. if stirred into the seed-bed at about 4 lb./acre immediately before sowing. The figures in Table IV show the results of one of our recent experiments.

TABLE IV

CONTROL OF WILD OATS IN PEAS

Application (lb./acre)	IPC		Chloro-IPC	
	Wild oats	Peas	Wild oats	Peas
To soil surface after sowing:				
0	35·4	23·3	35·4	23·3
4	23·5	22·9	40·7	21·1
8	28·8	22·6	19·4	23·8
12	28·8	21·4	26·9	21·6
Worked into seed-bed prior to sowing:				
0	49·2	23·7	49·2	23·7
4	10·8	21·8	7·6	21·1
8	7·0	22·1	4·9	22·8
12	5·3	23·4	1·7	27·1

Deeping St. Nicholas, 1954. Wild oats = plants per sq. ft.; application date: 15th April 1954; peas = plants per yard; weeds and peas counted: 18th May 1954.

The phenylcarbamates have not proved effective for the control of established perennial grasses. It remains to be seen whether 3-(4′-chlorophenyl) 1:1-dimethyl urea (Bucha and Todd, 1951) or some near relatives of α:α-dichloropropionic acid (Dow Chemical Co., 1953), which are also potent weedkillers, will be suitable for this purpose.

TABLE V

PRE-EMERGENCE WEED CONTROL TRIAL

Treatment	Rate (lb./acre)	Chickweed (*Stellaria media*) (plants/sq. ft.)	Groundsel (*Senecio vulgaris*) (plants/sq. ft.)
Control..	—	4·4	2·8
2:4:6-tribromo-phenylnitramine	10 15	0·1 0·0	0·7 0·3
2-chloro-9-fluorenol-9-carboxylic acid	5 10	0·1 0·0	0·3 0·0

Jealott's Hill. Treatment application: 16th April 1952; weed counts: 18th June 1952.

It is clear that a wide field for the use of chemicals for the control of growth and development of plants lies ahead. Even in the restricted field of weed control much will be accomplished in the next 10 years, and an example may be cited in which some novel compounds indicate yet another approach to new herbicides.

Several groups of compounds are known which, like *N*-(α-naphthyl) phthalamic acid (Mentzer and Nétien, 1950; Jones, Metcalfe and Sexton, 1954*a*), prevent seedlings responding to gravity and light in the normal way (Jones *et al.*, 1954*b*, 1954*c*). When seedlings germinate in soil containing these compounds, roots and shoots grow in random directions. It seemed likely that such compounds might be effective pre-emergence weedkillers, and Table V shows the results of a field trial carried out in 1952.

Unfortunately crop growth was markedly affected and these chemicals are not suitable as selective weedkillers. Further investigation of this antitropic effect may, however, yield academically interesting conclusions with perhaps practical applications.

ACKNOWLEDGMENT

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N.B. Where patent references are given the date shown is, for British specifications, the date of acceptance or publication and for U.S. specifications the date of issue; the dates of application are, of course, earlier.

THE CHANGING PATTERN OF ANIMAL HEALTH

W. T. Harrow

In Britain and other progressive countries striking improvements in animal health have followed recent advances in therapy, better veterinary services, and efficient legislation. Many infections that were looked upon as important not very long ago have been well controlled, lesser troubles have become of relatively greater concern as these declined, and science is at last gaining the upper hand in the unending struggle against disease.

As animal husbandry in each country progresses from the primitive to the modern, the pattern of animal health tends to alter in a more or less definite sequence. Under natural conditions, changes in animal health are brought about by the rise and fall of the great epidemic diseases—rinderpest, foot-and-mouth disease, and the like. As domestication comes in and veterinary knowledge is applied, these are gradually brought under control by such measures as vaccination, segregation, and eradication by slaughter. The "domestic diseases" or "diseases of overcrowding" then take their place in significance—helminthiasis, coccidiosis, foot-rot. These are reduced by chemotherapy and good management, and the "diseases of high production" appear—mastitis, and the so-called constitutional diseases.

In continents such as Africa the pattern can be seen in all its stages, but in Britain we now seem to be approaching its end. The initial stages of disease clearance are inevitably slow: it took us, for example, a hundred years to get rid of rinderpest; but with each success progress becomes more rapid, and within the past ten or fifteen years we have overcome many of our remaining troubles with remarkable speed.

There are several reasons for this, one of the foremost being an increased appreciation of the relative economic importance of the "domestic diseases" as compared with the major epizootics. Foot-and-mouth disease, for example, although perhaps more spectacular in its manifestation, costs this country only about half a million pounds annually, whereas losses from bovine infertility probably exceed twenty million. Nevertheless, before the war the attitude of the great majority of farmers to these diseases was more or less one of complacency or indifference, and relatively little was done to combat them, either by the individual or any official organisation. Because Britain is an island the major epizootic diseases can be kept out, or, if they do enter, they can be rapidly stamped out by vigorous control measures.

We have no such advantage in dealing with the endemic diseases, nor with such troubles as gastroenteritis and other parasitic conditions whose incidence is increased by the post-war intensification of stocking. There has been a marked rise in recent years in the demand for meat and poultry and dairy products, and here our island situation has proved a disadvantage, since it has required the keeping of more animals within the same limited area. The consequent growth in intensive production is probably most marked in the poultry industry: only 10% of birds were intensively reared in 1950 as against 35% in 1953, and it is predicted that the figure will be 50% by 1956.

Intensive stocking has a number of major effects on animal health. The economics of this system of husbandry require a quick turnover of invested capital, so that meat-producing animals and birds have to be slaughtered as soon as their growth period is over; the average age of our livestock population has therefore been reduced and diseases of young animals have increased in relative importance accordingly. Further, the keeping of animals closer together in larger communities augments the risk of spreading infectious diseases and brings about a higher concentration of parasites in the environment. Before the war the "domestic diseases" were therefore of rather less economic significance, and in any case very little could be done either in control or treatment.

Fortunately the position has been greatly improved since then. An outstanding instance is the progress made in the control of bovine tuberculosis. In pre-war years this disease infected at least 30% of our dairy cows, causing an annual loss of about 10% of the milk from each infected animal and heavy herd disposal wastage; even more important was the risk to human health, particularly in country districts where considerable quantities of unpasteurised milk were consumed. The establishment in 1950 of the Area Eradication Scheme, however, has now resulted in half of the national dairy herd being isolated into tuberculosis-free areas, and total eradication of the disease within the next ten years has been confidently forecast.

Bovine mastitis, which formerly affected 20–30% of our dairy cows, has now been halved in incidence owing to effective control of streptococcal mastitis through the use of antibiotics and of newer and more powerful antiseptics to prevent its spread. Staphylococcal mastitis, however, remains a problem, for it can only be controlled by antiseptics under certain circumstances, and treatment of individual cases is unsatisfactory.

Chemotherapy has been responsible for the control of several important diseases, notably the sulphonamides in foul-in-the-foot in cattle, calf scour, calf diphtheria, and coccidiosis. The use of benzene hexachloride dips was probably the ultimate factor in wiping out sheep scab, no outbreaks of which have been reported since 1952. Phenothiazine has also done much to reduce losses from parasitic gastroenteritis in sheep and cattle, and furazolidone is beginning to make headway against the Gram-negative bacterial diseases of poultry, such as fowl typhoid and "pullorum disease."

The development of new and more effective vaccines has brought about the control of many diseases which between the wars were responsible for great wastage. One of the worst of these was bovine contagious abortion, which at one time affected some 20% of our dairy cows. But a new type of attenuated vaccine was introduced from America during the war, and the Calf Vaccination Scheme of 1944 which provided for the vaccination of calves at very low cost to the farmer was so widely adopted that the disease has become of minor significance. Other diseases formerly of major importance and now readily controllable by vaccination include lamb dysentery, pulpy kidney disease, and swine fever.

Much has been achieved in a very short time. Control of the three major cattle diseases alone has already provided enough milk to give three million people a pint of milk daily for a year—their complete elimination would more than double this figure. Gains in meat and other animal produce have been substantial.

Unfortunately this is only one side of the picture. The other is not so bright. We still lose something like 10 lb. of mutton from internal parasites on each of the four and a half million sheep which are slaughtered each year, and despite the efficiency of anthelmintics against some of the worm parasites several important species remain uncontrolled. The liver fluke, for example, still costs us a sum approaching three million pounds each year.

It may be that nature has taken a hand in this particular disease, for the rabbit was known to harbour the fluke and to spread it from one district to another. Yet it is possible that by picking up cercariae which would otherwise have infected sheep the rabbit may have helped to keep down the numbers of larvae within an area, and hence that the present pattern of widespread chronic fluke disease may be replaced by a higher local incidence of liver-rot: certainly liver-rot has been unusually severe in many districts this year, and as the chronic form is amenable to treatment whereas the acute form is not, the pattern may not have changed for the better.

While some diseases remain unchanged, others are definitely increasing in their incidence. Vibrionic abortion, for example, which is alleged to have been disseminated from the Red Cross Sales of 1945, has rapidly grown in importance and seems to be taking the place of brucellosis in dairy cattle. Although several agents have some action against the causal parasite, they are difficult to apply effectively, and control has yet to be achieved in practice.

Changes in methods of feeding, particularly the use of leys and succulent fodder crops, appear to have increased the occurrence and severity of various metabolic disorders, such as frothy bloat, ketosis, and hypomagnesaemia. These conditions are the subject of increasing concern to the veterinary profession in all the high-producing countries.

Changes in the pattern of animal health similar to those in Britain have been taking place in other countries, and even where standards of husbandry are less advanced than our own intense efforts are being made to control animal disease. Trypanosomiasis is beginning to decline rapidly in many areas following the use of new chemotherapeutic and prophylactic measures, and rinderpest is being brought under control in countries where it has been a major problem for centuries.

There is still much to be done: Johne's disease, virus pneumonia in pigs, and leucosis in poultry are only three of the problems that remain to be solved; the death rate in young stock is far too high; metabolic disorders are not yet properly understood. Nevertheless the picture is more hopeful than ever before, and almost everywhere the use of modern methods and materials is changing the pattern for the better.

BOOK REVIEWS

Cotton Growing Problems, by B. G. Christidis and G. J. Harrison. Pp. 633, with line and half-tone illustrations. McGraw-Hill Book Co. Inc., New York. 1955. $9.75 net.

It is the specific aim of this book to help the cotton grower to choose the best methods of increasing the yield and quality of his crop. Experimental data from field tests on farming methods have been collected from the world's literature and are arranged and discussed with this end in view. About a fifth of the text is devoted to breeding and varieties; the rest covers all other field problems, from seeding to harvesting. Bibliographical references occupy 62 pages, and there are author and subject indices.

The authors claim that underlying principles for every problem bearing on cotton growing are discussed in the light of scientific developments, and with this approach to the subject it is singular to find no information on several botanical fundamentals, such as roots and rooting; certainly an introductory chapter describing the plant and its physiology would have been preferable to the sixteen blank pages so generously used as spacers. A few omissions were to be expected, but mention might have been made of the wide use of Cl IPC as a pre-emergence spray for the control of annual grasses and other weeds; also of the successful use of cuprous oxide as an alternative to organic mercurials for dressing against black-arm disease in Uganda.

These, however, are minor points in a work for which there is a real need today. In all cotton-growing countries except the U.S.A. the area under cotton has been expanded to record levels, but prices within the past three years have taken a downward trend, so that more attention must now be given to cutting the costs of production. The answer lies in applying the results of research, and by showing how this can be done *Cotton Growing Problems* serves a useful purpose.

E. J. MCNAUGHTON

Potato Diseases, by R. McKay. Pp. x + 126, with line, colour and half-tone illustrations. Irish Potato Marketing Co. Ltd., Dublin. 1955. 21s. net.

Any publication by a pathologist of Professor McKay's distinction may be assured of a welcome. His statement that this book is intended for those engaged in the potato trade is very modest, for it will certainly be very helpful to students of plant pathology as well, especially those engaged in advisory work.

Symptoms and control measures are clearly and concisely described, and in many cases a brief history of the disease and, where necessary, an outline of the life-history of the causal organism are given. Some literature references are appended for most diseases. The 107 photographs, including four coloured plates, are instructive and well selected and make it easy to identify the diseases. It is unfortunate that the coloured plates had to be limited to produce a book at such a reasonable price.

M. J. GEOGHEGAN

Diseases of Fruits and Hops, by H. Wormald (3rd ed. revised). Pp. 325, with half-tone and line illustrations and colour frontispiece. Crosby Lockwood & Son Ltd., London. 1955. 25s. net.

Since the publication of the first edition of Wormald's book much new information has been obtained, particularly through recent research work at East Malling Research Station on virus diseases of hardy fruits. The work on mineral deficiencies by Roach and Wallace has also been published since 1939, and these important contributions to our knowledge of nutritional needs of fruit trees could only be included as addenda in the second edition. The third edition has incorporated this new knowledge obtained during the war and post-war periods.

Dr. Wormald has faithfully corrected the few errors or discrepancies of the earlier editions. For example, magnifications of the diagrams are given, and some of the blank spaces in the plates have been filled with photographs of an equally high standard. The line drawings are disappointing in comparison, and it is a great pity the remaining blank spaces have not been filled by photomicrographs to replace the text figures. An attempt has been made to bring the account of fungicides in the second chapter up to date, but very scant information is given of the newer fungicides.

The book is primarily intended for fruit growers, but all others connected with horticulture will learn a great deal from perusing this modern and full account of diseases of fruits and hops in Britain.

The publishers are to be congratulated for maintaining such a high standard in their series of books for fruit growers. A great service to horticulturists overseas would be performed if a companion book on diseases of tropical fruits was published.

D. G. THOMAS

Progress in the Physiology of Farm Animals. Edited by J. Hammond. Volumes I and II. Pp. xv + 392 and xv + 740, with line and half-tone illustrations. Butterfield Scientific Publications, London. 1954 and 1955. 45s. net per volume.

Much research work has been done on various aspects of the physiology of farm animals over the last twenty years, and the purpose of the editor of these volumes is to present the advances in knowledge in an authoritative way to all interested in animal husbandry. Each chapter has been written by a specialist with the practical application of research findings well in mind.

Volume I deals with nutrition and metabolism, and environment. K. L. Blaxter reviews the wide field of the nutrition of ruminants and gives an up-to-date account of the parts played by rumen micro-organisms in carbohydrate and protein metabolism. R. Brande presents a very comprehensive review of the nutritional requirements of the pig and W. Bolton deals with poultry nutrition. D. P. Cuthbertson writes on the influence of trace elements on animal production.

The section on environment is opened by N. C. Wright, who examines work on the ecology of domesticated animals. J. D. Findlay and W. R. Beakley are concerned mainly with heat regulation in animals, J. C. D. Hutchinson with heat regulation in birds, and N. T. M. Yeates with the influence of daylight changes on reproduction and other physiological processes.

Volume II deals with animal growth, behaviour and locomotion, and with reproduction in poultry. R. W. Pomeroy reviews the influence of factors, such as plane of nutrition, sex and hormones, on liveweight growth. H. Palsson reviews very comprehensively factors affecting conformation and body composition of farm animals; the important research on the effect of plane of nutrition on conformation, of great interest to the meat market, is adequately covered. H. R. Marston discusses properties of wool and wool quality. D. E. Tribe in dealing with the behaviour of grazing animals discusses factors altering the grazing-ruminating pattern. A. Walton deals with sexual behaviour and the physiology involved. A mainly anatomical chapter is produced by C. W. Ottaway on the mechanism of movement. R. M. Fraps covers egg production and fertility in poultry.

W. S. FERGUSON

ABSTRACTS

CROP PRODUCTION

"Optimal depth of drainage." J. Wesseling and W. R. van Wijk, *Netherlands J. agric. Sci.*, 1955, **3**, 106–18.

The total amount of available water in the case of various water tables and root depths is calculated for a heavy clay soil and a sandy soil containing about 5% of humus from the moisture sorption curves of the soils, the moisture content at wilting point (i.e. the moisture not available to crops), the maximum uptake of moisture by plants at various depths, and the amount of water raised by capillary transport from the subsoil to the root zone. The maximum depth of drainage is that at which the available water in the soil equals the difference between rainfall and water requirement of the crop. Published figures for transpiration and water uptake by various crops are discussed, and it is concluded that under Netherlands conditions the root zone must contain 15 cm. of available water at field capacity. The root zone extends from the surface to a depth of 125 cm. for cereals, 100 cm. for potatoes, and 50 cm. for grass that is kept short by mowing or grazing. If more water is available than is required by the crops there is a danger that roots may be damaged through bad aeration, but the effect of this factor has not been calculated. S.F.A.

"Evaporation of water from soil under field conditions." G. Stanhill, *Nature, Lond.*, 1955, **176**, 82–3.

Undisturbed cores of soil were taken from a seed-bed, enclosed in watertight containers, and replaced in the seed-bed. Similar containers were filled with water and placed near them in the seed-bed. Total evaporation from the soil surfaces (by daily weighing) was plotted against total evaporation from the water. At first the losses were equal, but after a time, depending on the intensity of evaporating conditions, the soil loss became progressively less. Further experiments showed that the modification of the soil structure caused by sieving influenced the rate of evaporation of water from the soil surface independently of the apparent specific gravity of the soil. It was also found that even small differences in the moisture content of the top 3 in. affected the rate of evaporation. S.F.A.

"Compost from domestic refuse in Holland, its importance in agriculture and horticulture." Anon., *Fertil. Feed. St. J.*, 1955, **42**, 551–4, 557.

Town waste is treated on a large scale by the Van Maanen process, in which it is tipped, levelled, sprinkled with water that has already been used for other loads and therefore contains a large quantity of micro-organisms, and left to ferment for 3–4 months in winter or 6–8 months in summer. After fermentation the product, which no longer has an unpleasant smell, is ground and sold for compost. For small towns, where the plant is near the town the disintegration system is preferred, as it is odourless; the waste is ground first and then allowed to ferment for 4–6 weeks. In order to maintain good soil structure 7–10 tons of dry organic matter are needed per hectare per year. The proceeds from compost do not cover the cost of processing, but the difference is no more than the cost of other methods of refuse disposal. S.F.A.

"Foliar application of nitrogen to winter wheat." H. W. Gardner, *Agriculture, Lond.*, 1955, **62**, 267–9.

Three experiments were carried out in 1953 and three in 1954. In each case six treatments were given: no nitrogen, 'Nitro-Chalk' in late April, urea crystals in late April, urea spray in late April, urea crystals in late April followed by urea spray in late June, and 'Nitro-Chalk' in late April and again in late June. In two of the experiments there was no response to nitrogen top dressings; in the other four experiments top dressings in April increased yield of grain but had little effect on the percentage of protein in the grain, whereas June treatment had little effect on yield but increased the protein percentages. Percentage recoveries of nitrogen applied in April were 38% from 'Nitro-Chalk,' 32% from urea crystals and 27% from urea spray. 'Nitro-Chalk' and urea spray in June both gave 32% recovery. S.F.A.

"The intensive production of herbage for crop-drying. Part VI: A study of the effect of intensive nitrogen fertilizer treatment on species and strains of grass, grown alone and with white clover." W. Holmes and D. S. MacLusky, *J. agric. Sci.*, 1955, **46**, 267–86.

A five-year experiment was carried out in which twelve grasses or grass mixtures were compared under the following treatments: (1) no nitrogen, no clover; (2) no nitrogen, sown with clover at the same time as the grass; (3) 2 cwt./acre/cut of 'Nitro-Chalk,' no clover; (4) 4 cwt./acre/cut of 'Nitro-Chalk', no clover. For the last three years the clover sward was divided into three portions receiving the following amounts of 'Nitro-Chalk': none; 2 cwt./acre/cut; and 2 cwt./acre in spring and again in late summer. Mean yields for treatments (1), (3) and (4) were 2180, 5940 and 8300 lb. dry matter and 290, 850 and 1460 lb. crude protein. Significant differences were found between the grasses, yields being in the order cocksfoot > timothy/fescue > timothy > ryegrass. The yields of dry matter and crude protein per cut were compared over two years; the cocksfoot strains showed the most regular growth and the ryegrasses and meadow fescue the least regular; growth was most regular under treatment (4). Treatments (3) and (4) remained free from weeds and clover, but in treatment (1) the weed content was 10–13% in the second and following years and the clover content reached 13% in the third year. After the slow establishment in the first two years the clover treatments equalled or exceeded treatment (3) in yields of dry matter and crude protein. In the presence of clover yields were: ryegrass and meadow fescue > timothy > cocksfoot. The results from clover and added nitrogen suggested that increased shading of the clover was the most serious effect. The incompatibility of cocksfoot and clover is probably due to the rapid growth of cocksfoot. S.F.A.

"Alternatives to superphosphate." G. W. Cooke, *Agriculture, Lond.*, 1955, **62**, 27–30.

Recommendations, based on results of trials carried out by the Agricultural Research Council, are given for using ground rock phosphate, silicophosphate, dicalcium phosphate and nitrophosphate as alternatives to super. Gafsa rock phosphate supplied 60–90% as much P_2O_5 as super to swedes grown on acid soils (*p*H below 6·5) but was useless on potatoes grown on neutral soils (*p*H above 6·5). It is not recommended for the establishment of reseeded grassland but it may be used for maintenance. Silicophosphate, stated to be comparable to high-grade highly soluble basic slag, is equal in value to super on very acid soils (*p*H 5·5), while on neutral soils its efficiency is only ½–¾ that of super for swedes and potatoes. Dicalcium phosphate can be used as a substitute for super for most crops grown on acid or slightly acid soils. Three nitrophosphates were tested, each being made by a different process. On potatoes all were less effective than super but appear to have greater value on acid soils than on neutral soils. It is assumed that the value of basic slag is known. E.M.A.

"The mobilization of phosphate in waterlogged soils." J. K. R. Gasser and C. Bloomfield, *J. Soil Sci.*, 1955, **6**, 219–32.

The reducing conditions of waterlogging were simulated by anaerobically fermenting plant material; various phosphates were added, and the amount of phosphate in solution at intervals up to 50 days was compared with blanks in which water replaced the fermenting material. Phosphate was mobilised from all the calcium and iron phosphates (dicalcium phosphate, silicophosphate, rock phosphate, basic ferric phosphate and ferric hydroxyphosphate) but not from aluminium phosphate. With phosphated montmorillonite there was a rapid release of phosphate followed by readsorption and a second slower release; similar results were obtained with phosphated kaolin, but the proportion of phosphate mobilised was lower. When the solution from fermentation with ferric hydroxyphosphate was oxidised, the precipitate was more basic than the original ferric hydroxyphosphate, and a small but significant amount of phosphate was left in solution. These results agree with published work on the high-soluble phosphate after flood fallowing of sugar-cane fields and in poorly drained soils in north-east Scotland. S.F.A.

"Residual effects of phosphate fertilizers on a Wealden soil." G. W. Cooke and J. K. R. Gasser, *J. Soil Sci.*, 1955, **6**, 248–53.

Superphosphate or poultry manure was applied to beetroot and swedes, and the residual effects on potatoes grown the following year assessed by comparison with other plots in which small superphosphate dressings were applied each year. This two-year rotation was continued for six years. A fresh dressing of 0·2 cwt. P_2O_5 per acre as superphosphate gave yields of potatoes roughly equal to those given by 1·0 cwt. P_2O_5 per acre applied as superphosphate the year before. Slightly higher yields with poultry manure were attributed to the extra nitrogen, for which no allowance was made. Only 10% of the phosphate applied had been removed by the crops grown. Examination of soil samples suggested that much of the fertilizer phosphate applied had moved down the soil profile below the cultivated layer. S.F.A.

"Potash fertilizers." G. A. Cowie, *Agriculture, Lond.*, 1955, **62**, 236–8.

High-grade muriate of potash (60% K_2O) contains approximately 95% KCl; low-grade muriate of potash (40% K_2O) contains approximately 63% KCl, 16–33% NaCl and 0–10% magnesium compounds. The colour is no indication of purity. The impurities in low-grade potassic fertilizer may be of value for crops, but it may be more economic to buy the smaller bulk of high-grade fertilizer required to give an equivalent weight of potash, and to supplement it by special dressings as required, or rock salt or magnesium. For agricultural crops there is no advantage in using sulphate or potash rather than muriate, but for intensive market gardening and for very high yielding potato crops the sulphate is safer. In ordinary soils loss of potash by leaching does not exceed a few pounds per acre per year, but in very sandy soils and in shallow chalk or granitic soils, where leaching may be considerable, potash should not be applied to grass long before active spring growth. S.F.A.

"Elemental sulfur dust, a nutrient for lemon leaves." F. M. Turrell and J. R. Weber, *Science*, 1955, **122**, 119–20.

Tests were carried out with forked branches on the shady side of a lemon tree. The leaves of one half of each fork were covered with cellophane bags to protect them from sulphur dust; the leaves of the other half of each fork were dusted with elemental S^{35} dust and then similarly bagged. Leaves on distant parts of the tree were also bagged before the dusting took place. The leaves were harvested two months later. Sulphate in the untreated half-forks was less radioactive than that in the treated half-forks but considerably more radioactive than that from remote parts of the tree, suggesting that elemental sulphur is converted to inorganic sulphate which is transported to other locations in the plant. S.F.A.

"Iron nutrition of plants at high *p*H." P.C. de Kock, *Soil Sci.*, 1955, **79**, 167–75.

Mustard seedlings grown in nutrient solution at *p*H 7·8 were submitted to sixteen treatments: ferric chloride, ferric Versenate, ferric Versen-ol, or ferric Versene-diol combined with sodium chloride or sodium bicarbonate, and aerated with air (20% oxygen) or nitrogen containing 1% oxygen. Figures are given for average height and average fresh weight of plant, average dry weight, average ash, phosphorus and iron contents of roots, stems and leaves, and magnesium, potassium, calcium and sodium contents of leaves. Plants aerated with 1% oxygen contained more phosphorus in roots, less phosphorus in stems and leaves, and more iron in roots and stems than those with 20% oxygen. Chlorosis increased in the order Versene-diol < Versen-ol < Versenate < chloride in the sodium chloride treatments and Versene-diol < Versen-ol < Versenate = chloride in the bicarbonate treatments; it was more severe in the 20% oxygen set than with 1% oxygen, and in the bicarbonate set than with sodium chloride, except in the case of the Versene-diol-treated plants, all of which remained green. The ratio P/Fe was 60–70 in leaves of chlorotic plants and 40–50 in healthy leaves. S.F.A.

"Solubility of cobalt in soil." R. S. Young, *J. Soil Sci.*, 1955, **6**, 233–40.

Various forms of cobalt were mixed with the top 25 mm. of soil in percolators and rainwater added every three days. Amounts of cobalt dissolved after 1, 3, 6 and 9 months were: nitrate 61%, 82%, 84%, 85%; chloride 29%, 75%, 82%, 83%; sulphate 39%, 69%, 73%, 75%; phosphate nil, nil, 1·94%, 3·43%; carbonate 0,02%, 0·04%, 0·93%, 1·18%; oxide 0·05%, 0·07%, 0·11%, 0·19%; metal nil, nil, 0·03%, 0·09%. The samples were then leached with 0·1N hydrochloric acid on twelve successive days: this extracted all the residual cobalt from the nitrate, chloride and sulphate, 83·3% of the residual cobalt from the phosphate, 51·1% from the metal, 13·2% from the carbonate and 2·9% from the oxide. S.F.A.

"Cessation of tillering in young grass plants." A. Troughton, *Nature, Lond.*, 1955, **176**, 514.

Field trials, in which 660 plants were dug up twice a week and the tillers counted and weighed, were reported in *J. Agric. Soc. Univ. Coll. Wales*, 1954, **35**, 29. In continuation of this work, plants of *Lolium perenne* were grown in 6·7-litre whalehide pots. Tiller production ceased about the hundredth day after sowing. As in the field experiment, there was no cessation of dry-weight increase comparable to the cessation of tiller production, although a gradual reduction in this rate did occur. The weight of shoot per tiller increased at the same rate throughout the period. S.F.A.

"Studies on lucerne and lucerne-grass leys. 1: Summer and autumn management of a lucerne-grass mixture grown on heavy land." M. G. Barker, F. Hanley and W. J. Ridgman, *J. agric. Sci.*, 1955, **46**, 361–76.

Yields and nitrogen contents of oven-dried lucerne and grass, yields of weeds, and botanical composition (point quadrat method) were observed over the period 1946–51 on established lucerne-cocksfoot leys cut or grazed by cattle in July and cut or grazed by sheep in late September or late October. Whenever the effects of grazing in July differed significantly from those of cutting the difference was in favour of grazing, but the effects of autumn grazing were less consistent. Grazing in July and autumn or cutting in July and autumn gave higher yields the next July than grazing followed by cutting, or vice versa. Date of autumn cutting or grazing had no effect on the total yield of herbage, but October defoliation gave better growth, yield and persistence of lucerne in following years whereas September defoliation gave better growth of grass. S.F.A.

"Summer and winter feeding from grass-lucerne drills. G. Pearson Hughes, *Agriculture, Lond.*, 1955, **62**, 115–17.

This describes a method devised to extend the grazing season to provide both winter and summer feed for fattening beef cattle without the use of supplementary feeding and without the loss of carcass quality. Lucerne and grass were sown in separate drills in rows a foot apart. This was found to overcome the competition between the lucerne and grass and the effect of nitrogen fertilizer which is usually detrimental to the legume in a grass/legume sward. Seeds mixtures tested have been cocksfoot/lucerne; timothy/meadow fescue/lucerne; perennial ryegrass/lucerne; tall fescue/lucerne. Of these cocksfoot and tall fescue sown in rows alternate to lucerne have given the best results. Grasses have provided the winter feeding with the lucerne growing away well in the spring to give a balanced legume grass sward. E.M.A.

"The effect of chopping, lacerating and wilting of herbage on the chemical composition of silage." J. C. Murdoch and others, *J. Brit. Grassl. Soc.*, 1955, **10**, 181–8.

The quality of silage made from lacerated, chopped and unchopped lucerne/timothy or meadow fescue herbage was compared. The chopped herbage received an addition of undiluted molasses at the rate of 48 lb./ton. The effect of wilting for about 24 hours was also studied. Preliminary trials first investigated the effect of chopping and lacerating on the formation of acids in the silage. After 14 days the *p*H of the silages were: lacerated, 3·9; chopped, 4·0; unchopped, 4·3. The main experiment was carried out over two years, and figures are given for percentages of dry matter, crude protein, ether extract, crude fibre ash, *p*H, organic acids, volatile bases and amino-acid contents of the silages. Chopped and lacerated silages contained considerably less butyric acid than the unchopped unwilted silage. Chopping and lacerating appear valuable aids in the proproduction of high-quality silage, but their use will not necessarily produce excellent silage. Chopping together with molasses gave high grade silage and wilting a well-preserved product with low contents of acids and volatile bases. Chopping or lacerating of the wilted crop increased acid content and controlled temperature. E.M.A.

"The ensiling of lucerne with addition of formic and glycollic acids, molasses and barley meal, and with wilting." J. C. Murdoch and others, *J. Brit. Grassl. Soc.*, 1955, **10**, 139–50.

Investigations were carried out in eight brick tower silos with capacity 15–25 tons and four small pipe silos with capacity 10 cwt. chopped material. Three cuts were taken of the lucerne/timothy sward, the timothy being much reduced in the second and third cuts. Treatments were: 16 lb. glycollic acid (56%) and 22 lb. formic acid (85%) per ton diluted to 15 gal. acid per ton of crop; 60 lb. molasses diluted to 2 parts molasses to 1 of water; 1 cwt. barley meal per ton green chopped crop. Figures are given for the dry matter, crude protein, ether extract, N-free extract, crude fibre ash and true protein for the lucerne crop and the silage and the dry matter and crude protein content of the effluent. Losses of nutrients, including carotene are also given. The acid and barley meal treatments gave the best silages, but in the case of the latter it is thought that chopping had a considerable effect. Wilting gave a well-preserved silage, but overheating in the mass affected the crude protein digestibility and carotene contents. Molassed silage had the poorest quality. E.M.A.

"Plane of nutrition and starch equivalents." K. L. Baxter and N. McC. Graham, *J. agric. Sci.*, 1955, **46**, 292–306.

Experiments with two sheep are described in which energy retention was measured at different levels of food intake and the losses of energy incidental to food consumption measured. It was found that the relationship between energy retention and food intake expressed as metabolisable energy is not linear but exponential. If the nutritive value of the food given to animals is not constant but determined by the amount given, a new method of calculating livestock rations is needed in which requirements and food intakes are scaled by nutritional plane and metabolic body weight. Satisfactory results are obtained when the calculation is applied to published data. S.F.A.

CROP PROTECTION

"A new acaricide, 2,4,5,4′-tetrachlorodiphenylsulphone." H. O. Huisman, R. van der Veen and J. Meltzer, *Nature, Lond.*, 1955, **176**, 515–16.

"Tedion V18" (2,4,5,4′-tetrachlorodiphenylsulphone) and 2,4,5-trichlorodiphenylsulphone have been found to be strongly acaricidal without having the phytotoxic properties of other diphenylsulphones. At 100 p.p.m. Tedion V18 gave total kills of all except adult stages of the common red spider mite *Tetranychus telarius*; as an ovicide it was more active than some newer acaricides now in use, such as CPBS, CPCNS, and *p*-chlorophenyl-*p*-chlorobenzyl sulphide. Insects exposed to a dry residual film were not harmed, nor were bees poisoned by contact or ingestion. In orchard trials against the fruit tree red spider mite *Metatetranychus ulmi*, almost complete control was obtained from a single post-flowering treatment. Seedlings of cucumber, tomato, potato, broad bean, french bean and pea were unharmed after having been sprayed with 3·0% active material. The mammalian toxicity of Tedion V18 is low, the MLD for mice being greater than 5 g./kg. D.L.

"The glasshouse red spider mite on blackcurrants." C. A. Collingwood, *Ann. appl. Biol.*, 1955, **43**, 144–7.

The natural host-plant range of the glasshouse red spider mite *Tetranychus urticae* is very wide, but its occurrence as a pest on blackcurrants appears to be related to the effects of DDT sprays on its predators. Established infestations have been found to persist for many years. Control by contact insecticides has failed to give satisfactory control, mainly because of the difficulty in thoroughly wetting the under surface of blackcurrent leaves. Parathion has given good immediate kills, but sharp population increases have followed; better results have been obtained with TEPP. Systemic sprays and summer ovicides have been more promising, maximum benefit resulting from two sprays in May rather than from later applications. D.L.

"Experiments in the control of *Metatetranychus ulmi* with the product R. 6199." (In Italian, with English summary.) R. Grandori and P. A. Rota, *Boll. Zool. agr. Bachic.*, 1955, **21**, 53–68.

In Italian trials with R. 6199 against the fruit tree red spider mite *Metatetranychus ulmi* in 1954, populations on apple trees were eliminated by two sprays of 27·5 p.p.m. at a weekly interval (28th July and 4th August). All mites were killed within two weeks, and there was no reinfestation. A single spray at the same strength in June was as effective within four weeks, but there was a slight reinfestation in mid-September. Total kills were obtained within a week using R. 6199 at 50 p.p.m. but the results were not so long-lasting. D.L.

"Large-area tests of a male-annihilation method for oriental fruit fly control." L. F. Steiner and R. K. S. Lee, *J. econ. Ent.*, 1955, **48**, 311–17.

Experiments in Hawaii have shown that infestations of the oriental fruit fly *Dacus dorsalis* can be reduced by 60–100% if male flies are destroyed before they can fertilize the females. In a 28-month experiment on Oahu in an area with an abundance of wild hosts, about fifty feeding stations treated with methyl eugenol and parathion attracted and killed more than three million male flies. Mean infestations in four successive guava crops ranged from 1·2 to 4·2 larvae per pound in the treated area, and from 7·1 to 35 per pound in similar untreated regions. D.L.

"The effects of defoliation and loss of stand upon yield of sugar beet." F. G. W. Jones, R. A. Dunning and K. P. Humphries, *Ann. appl. Biol.*, 1955, **43**, 63–70.

Sugar-beet seedlings are defoliated by such pests as the mangold fly *Pegomyia betae*, whereas wireworms (*Agriotes* spp.) and millipedes (*Blanjulus guttulatus*) cause loss of stand and many other pests cause damage of both types. In field trials with simulated insect injury it was found that about 50% defoliation in the four-leaf or eight-leaf stages caused only 5% decrease in root yields at harvest, and complete defoliation no more than 30% decrease. Similarly, loss of half the stand caused a reduction in root yield of 10%. Good recovery can be expected from most pest attacks, few of which cause more than 50% defoliation or loss of stand. D.L.

"Evidence of injury to deciduous fruit trees by an ectoparasitic nematode (*Xiphinema* sp.) and a promising control measure." R. E. Adams, *Phytopathology*, 1955, **45**, 477–9.

Injury to the roots of old apple trees in Virginia by an eelworm (*Xiphinema* sp.) was thought to cause a condition known locally as "pout." Such trees improved and eelworm populations in the soil were reduced by watering the ground beneath trees with BHC (10% γ isomer) suspended in water at 30 g./100 sq. ft. The fruit was not tainted. Increased growth, apparently due to control of *Xiphinema* sp., was also obtained in young peach and apple trees. D.L.

"The combined use of nematicidal soil fumigants and solubilized .chemicals." B. G. Peters, *J. Helminth.*, 1955, **29**, 81–6.

A disadvantage of soil fumigants, when used at such a rate as to kill eelworms (*Heterodera* spp.) at depths between 2 and 10 in., is that ventilation of the surface soil prevents the accumulation of a lethal concentration in the surface layer. This inefficiency is only moderately reduced by using water or foil seals. From glasshouse experiments at Rothamsted Experimental Station it has been found that if DD soil fumigation is followed by a soil surface treatment the two treatments behave independently and give total kills. A satisfactory surface treatment was to drench the soil with a 1% mixture of para- and metacresols 50/50, solubilised in water with 0·5% Teepol. D.L.

"Factors influencing the emergence of larvae from cysts of the beet eelworm *Heterodera schachtii* Schmidt." H. R. Wallace, *J. Helminth.*, 1955, **29**, 3–16.

Experiments at constant temperatures showed that 25° C., of the temperatures tested, induced optimum larval emergence from cysts of *H. schachtii.* Higher emergence rates were thought to occur under the influence of fluctuating temperatures. The rate of emergence in beet diffusate increased as the initial oxygen concentration increased; pretreatment of cysts at low oxygen concentration or at fluctuating oxygen concentrations reduced emergence. Emergence was also reduced by exposing cysts to different saturation deficiencies and by pretreatment at high saturation deficiencies. Larval emergence depended on the moisture characteristics of the soil. D.L.

"Seedling blight, a fusarial disease of asparagus." K. M. Graham, *Canad. J. Bot.*, 1955, **33**, 374–400.

The incidence of seedling blight of asparagus caused by *Fusarium oxysporum* var. *redolens* in Ontario was correlated with the proximity of mature plantations or with the presence of soil debris from an earlier crop. The optimum soil temperature for disease incidence was 25–30° C.; above 30° C. fungal growth was inhibited and asparagus emergence was more rapid. The pre-emergence phase of the disease was favoured by the retarded emergence at temperatures below 20° C. Symptoms increased with high and low soil-moisture levels. Under greenhouse conditions, disease incidence increased when leguminous rather than non-leguminous debris was present in the soil, and there was some evidence that saprophytic growth of the pathogen was more profuse on certain non-living substrates. Penetration of the host occurs in the embryonic region of the root tip, or through stomata on the hypocotyl. Unlike most *Fusarium* spp., the organism is limited to the cortex rather than to vascular tissue. D.L.

"On the killing of plant cells by enzymes from *Botrytis cinerea* and *Bacterium aroideae*." H. T. Tribe, *Ann. Bot.*, n.s., 1955, **19**, 351–68.

Enzyme preparations obtained from culture filtrates of the soft-rot organisms *Botrytis cinerea* and *Bacterium aroideae* decreased the viscosity of pectin and pectate solutions, macerated parenchymatous tissue of such higher plants as the potato, and killed cells in tissues so macerated. *B. cinerea* enzyme preparations were active from about *p*H 3·5 to *p*H 6·0, but their activity rapidly decreased from *p*H 6·0 to almost nil at *p*H 8·0. Conversely, *B. aroideae* preparations were most active above *p*H 8·0 and were almost nil at *p*H 5·5. Both enzymes lost much activity on prolonged dialysis against distilled water, and this was not recovered on re-addition of the dialysed salts. Plasmolysing concentrations of salts or non-electrolytes greatly retarded the killing action of the enzyme preparations. D.L.

"Strawberry *Botrytis* rot (grey mould) control: a field trial of captan at East Malling." A. H. M. Kirby, M. H. Moore and Dorothy J. Wilson, *J. hort. Sci.*, 1955, **30**, 220–4.

The combined effects of grey mould, caused by *Botrytis cinerea*, and irrigation on strawberry cropping were examined in a two-year field experiment. In both years two post-blossom sprays of captan 50% wettable powder were applied to plants and strawed alleys at 2 lb./100 gal.

at an average rate of over 700 gal./acre. The application of captan reduced the number of rotted fruit and increased the yield, especially on irrigated crops. The marketable crop was increased by 30% in two years. Hose irrigation increased the losses due to rotting on plots receiving no fungicide, but gave higher yields on treated plots. Where irrigation is practised it is recommended that fungicide applications will give maximum advantage.
D.L.

"Streptomycin sulfate for the reduction of bacterial soft rot of packaged spinach." W. L. Smith, *Phytopathology*, 1955, **45**, 88–90.

An aqueous solution of streptomycin sulphate at 1000 p.p.m., sprayed on spinach between one and five days before harvest or used as a ten-minute dip after harvesting, gave almost complete control of decays in packaged spinach caused by *Erwinia carotovora* and *E. atroseptica*. The control was not effective after two days on spinach packed in plastic bags.
D.L.

"Reversal of the fungicidal effect of dithiocarbamyl compounds." J. Goksøyr, *Nature, Lond.*, 1955, **175**, 820–1.

A study was made of the inversion of the fungicidal effect of dithiocarbamyl compounds at intermediate concentrations. The action of sodium dimethyldithiocarbamate in the presence of copper and zinc sulphates was shown to be due initially to a growth inhibition caused by the formation of the 1 : 1 copper complex, followed by a reversal due to the transformation to the normal 1 : 2 copper complex; when all the copper has been chelated, an inhibition occurs due to the formation of the zinc compound. Similar results were obtained with thiram and tetramethylthiuram monosulphide, when *Saccharomyces cerevisiae* was used as the test organism.
D.L.

"Sugar-beet yellows in California." C. W. Bennett, *Sug. Beet Bull.*, 1955, **19** (2), 10–11.

In 1952 half the plots in two fields of sugar beet were treated with insecticides to control the aphid vectors of yellows, while the remainder were left untreated. The sucrose content of beet from the treated plots was reduced by 7·8%, and from the untreated plots by 39·7%; the yield from the untreated plots was 12 tons per acre less than that from treated plots. In 1953 and 1954 comparisons were made between healthy plants and those inoculated with a severe virus strain. The sucrose content of the sugar beet was reduced by 35·8% and 45·3%, and the average yields in tons per acre were reduced from 28·8 to 18·7 and from 38·7 to 24·3.
D.L.

"A new approach to selective weed control." R. L. Wain, *Ann. appl. Biol.*, 1955, **42**, 151–7.

Wheat cylinder, pea curvature and tomato epinasty tests with various dichloro- and methyl-chloro-ω-phenoxyalkylcarboxylic acids showed that homologues with an even number of carbon atoms were degraded, probably by β-oxidation, to the active acetic derivative, whereas those with an odd number of carbon atoms were inactive. Similar results were obtained with 2,4,5-substituted ω-phenoxyalkylcarboxylic acids in the wheat cylinder elongation test, but in pea curvature and tomato epinasty tests all homologues higher than the acetic were inactive. Further tests have shown that some important crops such as clover and lucerne are unaffected by certain ω-phenoxybutyric acids which are rapidly converted to the active phenoxyacetic derivatives in the tissues of many weeds.
S.F.A.

"The early spray catches the weed." K. Carpenter, *Frms.' Wkly*, 1955, **43**, 83–5.

This is a discussion of the performance of MCPB (methyl-chloro-phenoxybutyric acid) during its first season of commercial usage. The activity of this weedkiller is caused by its breakdown within the plant to MCPA. Weeds controlled by MCPB are, with few exceptions, the same as those affected by MCPA and 2,4-D. One exception is the cabbage family (yellow charlock, mustard and pennycress). The effect of temperature on the action of the new weedkiller is very marked. Greater precision is needed in the time of application of MCPB than with MCPA, so that weeds such as charlock, poppy and pennycress can only be controlled easily at the rosette stage; most other annual weeds are susceptible at the 4–6 leaf stage. Good coverage of weed leaves is essential at rates of 15–25 gal./acre. Spraying undersown cereals with clover only in the one-leaf stage caused no reduction in density even when MCPB was used at 1½ lb./acre. Further confirmation is needed before MCPB can be recommended for use on cereals at an early growth stage. Some varieties of peas appear resistant to MCPB, but as yet no recommendations are being made for use of this weedkiller in the pea crop.
E.M.A.

"Selective weed control in direct-sown leys." F. E. Alder, *Agriculture, Lond.*, 1955, **62**, 62–3.

Good results are reported with dinoseb (2,4-dinitro-6-sec-butyl phenol) against poppy in red clover and runch in perennial ryegrass/white clover. Grasses may be sprayed at the 3–5 leaf stage with one developed tiller, alsike clover at the 1–2 true leaf stage, white clover at the 2–3 trifoliate leaf stage, and red clover and lucerne at the 4–5 true leaf stage. Leaf scorch will occur, but the plants recover quickly. The one drawback of dinoseb is the care required in handling it. It may be superseded by MCPB (4-chloro-2-methylphenoxybutyric acid), which is safe to apply to clovers but which does not control mayweed, cleavers and chickweed.
S.F.A.

"Plant growth regulators. 1: The influence of side-chain length on the activity of ω-(2-naphthyloxy)-*n*-alkylcarboxylic acids for the induction of parthenocarpy in tomatoes." L. C. Luckwill and D. Woodcock, *J. hort. Sci.*, 1955, **30**, 109–15.

Ten ω-(2-naphthyloxy)-alkylcarboxylic acids, $C_{10}H_7O(CH_2)_nCOOH$ in which n varied from 1 to 11, and six of the corresponding 3-chloro compounds ($n = 1, 2, 3, 5, 7, 9$) were tested. In the non-halogenated series only those members having an even number of C atoms in the side chain (n = odd number) were active. This might be due to β-oxidation, which would result in conversion of compounds with an even number of C atoms to 2-naphthyloxyacetic acid and those with an odd number of C atoms to the inactive β-naphthol, but there is no experimental evidence of this. The compounds with four and six carbon atoms in the side chain were as active as 2-naphthyloxyacetic acid, but further increases in the side chain led to a marked decrease in activity, probably due to poor penetration of the larger molecules into the cell. The introduction of a chlorine atom in the 3 position did not affect the activity of 2-naphthyloxyacetic acid but completely destroyed the activity of higher homologues, probably by blocking β-oxidation.
S.F.A.

ANIMAL HEALTH

"Acute poisoning of cattle by common ragwort (*Senecio jacobaea* L.)." R. S. Coburn and others, *Vet. Rec.*, 1955, **67**, 640.

This reports 43 deaths in a herd of 65 Friesian in-calf and maiden heifers yarded and fed for a short time on cubes prepared from lucerne cut from a field heavily infested with common ragwort. The individual intake averaged 8 lb. daily. Dullness and listlessness were followed by the principal poison symptoms, acute diarrhoea, persistent straining, staggering, partial blindness and excitability. Onset of these symptoms took place some 5–10 days after initial feeding and the first death within a fortnight. Post-mortem examination revealed inflammation of the abomasum and hepatic cirrhosis. Ragwort in its early stages of growth is not normally eaten by stock, and it appears that the lucerne masked the unpalatability. With the growing development in grass conservation great vigilance against ragwort must be demanded, since, as shown by this case, processing does not destroy the toxic nature of ragwort. E.M.A.

"Hypomagnesaemia in dairy cattle and its possible relationship to ruminal ammonia production." M. J. Head and J. A. F. Rook, *Nature, Lond.*, 1955, **176**, 262–3.

Recent investigations at the N.I.R.D. have dealt with changes in blood composition, rumen fermentation and mineral metabolism which take place when dairy cattle are transferred to spring grazing or fed cut spring grass. Figures are given for the fall in urinary excretion of Mg and the blood serum Mg level indicating low availability of Mg in spring grass to dairy cows, probably due to alimentary disturbances. Trials were carried out to determine the effect of feeding 1250 g. ammonium acetate and ammonium carbonate per cow after observation that the ammonia content of the rumen increased with spring grazing. Falls in urinary excretion of Mg and blood serum levels took place comparable to those occurring on spring grass. Lower levels of the ammonium salts had no effect. It is suggested that hypomagnesaemia of cows on grass is caused by inadequate adsorption of magnesium associated with high ammonium content of the rumen. The recovery of the blood serum Mg level as the grass matures and the nitrogen content falls could also be explained by the critical nature of rumen ammonia level. E.M.A.

"Possibilities of insect control or eradication through the use of sexually sterile males." E. F. Knipling, *J. econ. Ent.*, 1955, **48**, 459–62.

Research on the screw-worm *Callitroga hominivorax* has shown that an insect population can be materially reduced by the release of large numbers of sterile males. Before the procedure can be regarded as feasible for the control of any given pest, five points need consideration: (1) a mass-rearing method must be available; (2) adequate dispersion of the released males must be obtained; (3) the mating behaviour must not be adversely affected by the sterilisation procedure; (4) the female should mate only once, or, if more frequent matings occur, sperm from sterile males must compete with that from fertile males; and (5) the population density of the insect must be such that it is possible to release a dominant population of sterile males within a definite period. It is suggested that the method should prove suitable for the control of pests present in small numbers (such as cattle grubs, *Hypoderma* spp.), for newly established infestations before the affected area becomes large or the population high, and as an adjunct to other control measures. D.L.

"Screw-worm control through release of sterilized flies." A. H. Baumhover and others, *J. econ. Ent.*, 1955, **48**, 462–6.

A large-scale field experiment was conducted on the island of Curaçao to test whether an isolated population of the screw-worm *Callitroga hominivorax* could be eradicated by the release of sterilised flies. The flies were reared in Florida and distributed by plane within twenty-four hours of emergence; they were sterilised by gamma irradiation as five-day-old pupae. In early stages of the experiment males were released at the rate of about 100 per square mile each week, but only 15% of females laid infertile eggs. Release rates of 107 and 450 per square mile caused 30·6% and 48·9% sterility. In the final two months of the trial (August to October) 435 males per square mile were released each week, and the percentage of sterile egg masses increased from 69 to 100. The population declined by more than 99% in eight weeks; except for two egg masses collected after 12 and 13 weeks there was no evidence of normal fly activity after the eighth week of releases, and after a further eight weeks the screw-worm was believed to have been eradicated. D.L.

"The use of gamma radiation for control or eradication of the screw-worm." A. W. Lindquist, *J. econ. Ent.*, 1955, **48**, 467–9.

The release of sterilised screw-worm flies *Callitroga hominivorax* having been successful in eradicating the pest from the island of Curaçao, attention has been directed to the use of the technique in certain States of the U.S.A. The obstacles to its use in Florida do not appear to be insurmountable, and after initial surveys an eradication programme will probably be attempted. The cost would be considerable; for Curaçao 150–200 thousand flies were reared each week, and Florida is some 300 times larger than Curaçao. Eradication in Texas does not appear practical because the pest is also present in Mexico, but temporary control might be achieved in overwintering areas of the State. D.L.

"Temporary destocking of pastures to aid control of the cattle tick." P. R. Wilkinson, *Nature, Lond.*, 1955, **176**, 515.

Destocking of pastures has frequently been practised in tropical Australia during campaigns for the eradication of the cattle tick *Boophilus microplus*, but the procedure has also been found of value as a control measure in itself. By alternating cattle between paddocks and spraying six times annually with 1% DDT, infestations were greatly reduced compared with those encountered on cattle receiving eight sprays each year in single paddocks. The occurrence of a few ticks was considered desirable, as immunity to redwater fever was thereby maintained. D.L.

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